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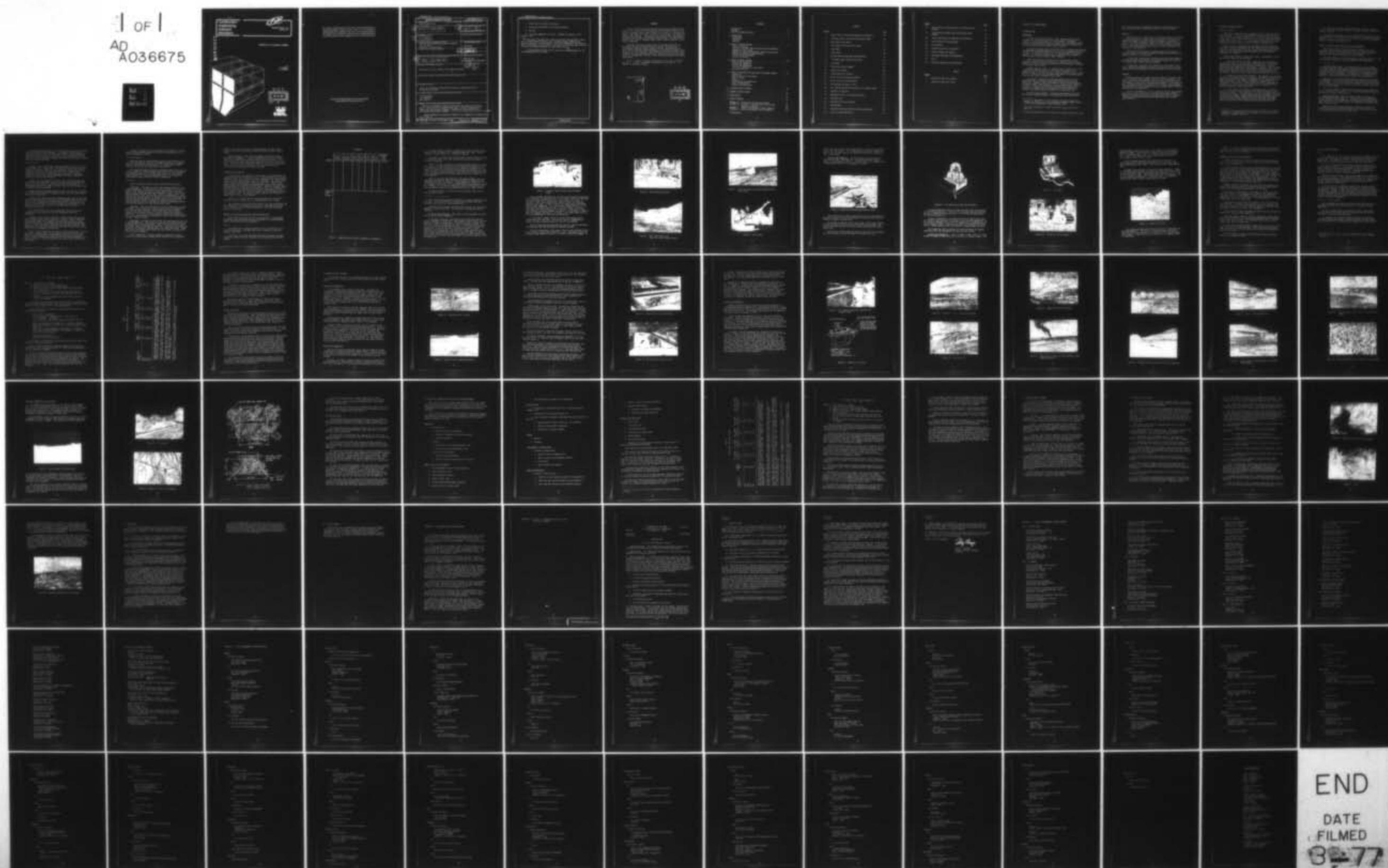

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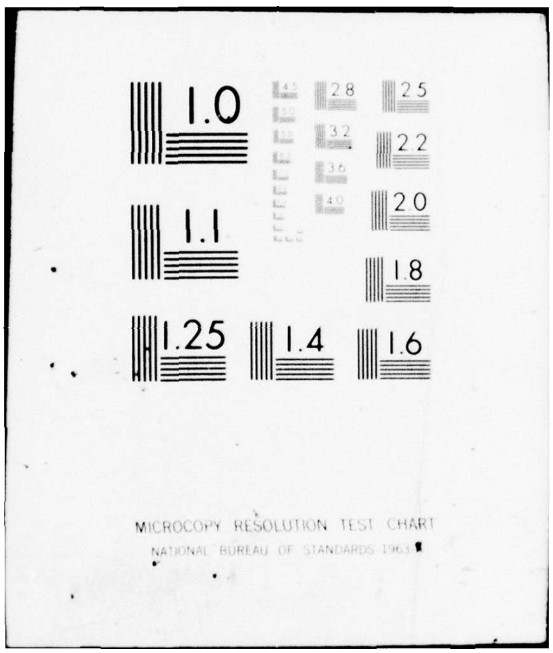
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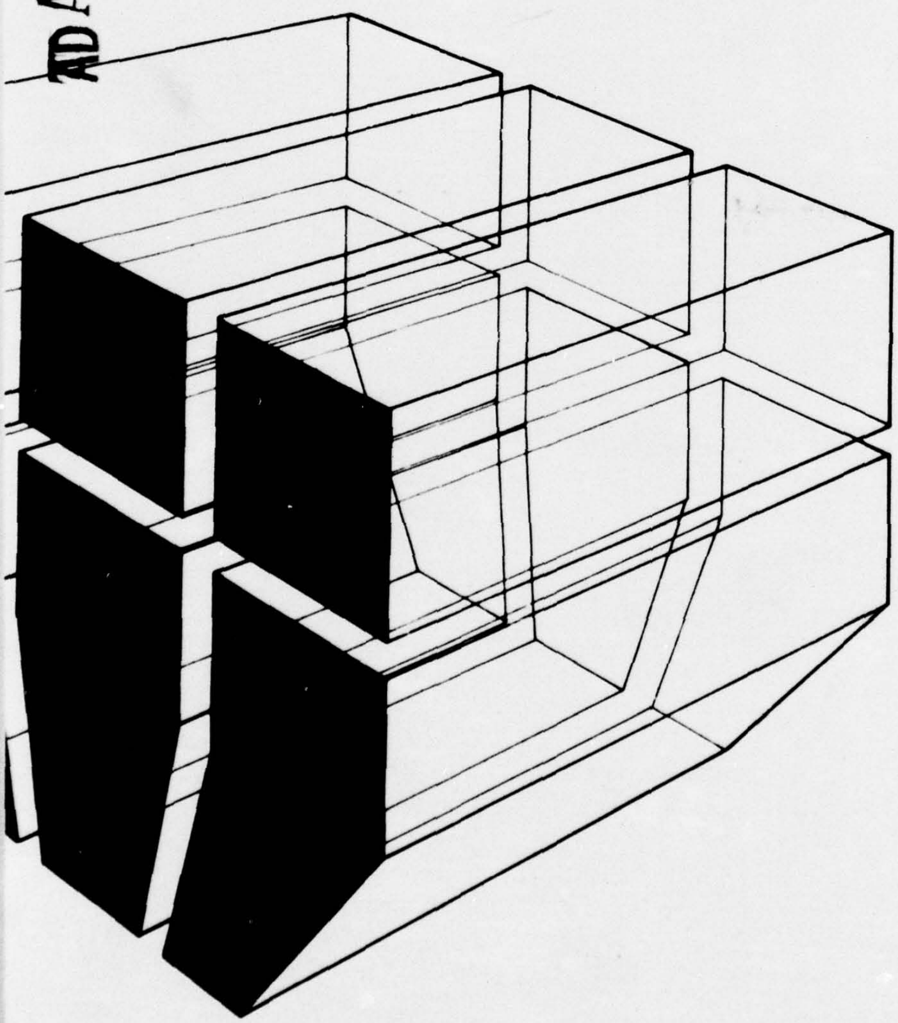

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Recent environmental legislation has made the disposal of clearing debris a more difficult problem at dam sites. Corps of Engineers personnel must now consider a number of complex and interacting factors when determining disposal methods.

Several methods can be used to dispose of cut vegetation, including but not limited to:

1. Burial with or without processing

2. Burning by unconfined or confined techniques

3. Selling

4. Using the vegetation for mulch, firewood, to construct fish habitats, etc.

Investigators reviewed many clearing contracts and pertinent literature, visited several projects, and discussed disposal methods with personnel working on Corps projects. From this information, the investigators developed a list of factors that should be considered when selecting clearing and disposal methods for a particular site.

The study determined that no one clearing or disposal method can be used economically at all sites.

FOREWORD

The U.S. Army Construction Engineering Research Laboratory (CERL) conducted this study for the Directorate of Civil Works, Office of the Chief of Engineers (OCE), under Program Title (Level II) "Environmental Impact," CWIS Work Unit 31055, "Disposal of Solid Wastes from Reservoir Clearing and Cleaning." The work was performed by CERL's Environmental Engineering Team (ENE), Environmental Division (EN). The OCE Technical Monitor is Mr. John B. Bushman; the Assistant Technical Monitor is Mr. John S. Robertson.

Personnel from the following Corps of Engineers Districts and Divisions provided information for this report: Baltimore and Philadelphia Districts, North Atlantic Division; Portland District, North Pacific Division; Omaha and Kansas City Districts, Missouri River Division; St. Louis District, Lower Mississippi Valley Division; South Atlantic Division; Huntington District, Ohio River Division; and Tulsa District, Southwestern Division. Their time and assistance are greatly appreciated.

Mr. W. J. Mikucki is Chief of ENE and Dr. R. K. Jain is Chief of EN. COL J. E. Hays is Commander and Director of CERL and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

In 1970, the Corps of Engineers (COE) developed approximately 154,000 acres (61 600 hectares) of land for water impoundment projects.[1] Clearing operations were conducted on an estimated 42,000 acres (16 800 hectares) of forested land and generated approximately 2.2 million tons (2 million metric tons) of debris.

Projected estimates indicate that the COE will develop approximately 116,000 acres (46 400 hectares) of land for water impoundment projects in 1980.[2] An estimated 36,000 acres (14 400 hectares) of forested land will be cleared at these projects, generating approximately 2.4 million tons (2.2 million metric tons) of debris.

Though these figures are not exact, in the absence of more substantial data they are considered to be adequate for this report. Appendix A provides a detailed explanation of the procedures followed to calculate these figures.

Although COE will clear *less* forested land in 1980 than in 1970 (6,000 acres [2400 hectares]), it will have to dispose of *more* vegetative debris (0.2 million tons [0.18 million metric tons]), since the U.S. Forest Service has predicted that there will be more vegetation per unit area of forested land in 1980.[3]

In the past, contractors at COE dam projects used the least expensive means to dispose of wood debris generated by clearing operations. However, recent environmental laws have made disposal of clearing debris more difficult; it is no longer solely a matter of economics. Today, COE planning and construction personnel must consider many complex and interacting factors when selecting an appropriate disposal method or methods for a particular site.

To assist Corps personnel in selecting environmentally acceptable debris disposal methods, a four-phase study was initiated in

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[1] *Solid Waste Management in Land Clearing and Logging Operations*, Appendix B, Table B-6 (U.S. Environmental Protection Agency, Office of Solid Waste Management Programs, October 1973).

[2] *Solid Waste Management in Land Clearing and Logging Operations*, Table B-7.

[3] *Solid Waste Management in Land Clearing and Logging Operations*, p 23.

FY73 to develop overall management concepts for disposing of solid waste from clearing and cleaning operations at COE impoundments.

Objective

The purpose of this report, which covers Phase Three of the study, is to provide planning, construction, and operations personnel with information needed to evaluate different methods for disposing of debris. The report summarizes findings of research dealing with the extent of the clearing problem, types of clearing methods available, costs, and environmental and other practical issues involved in the disposal of clearing debris.

Phase One studied available equipment that could be used to dispose of debris, particularly chipping equipment and equipment that could be used for pit incineration.

In Phase Two, investigators considered the information needed by planning and operations personnel to evaluate methods for disposing of cleaning debris removed from impoundments.

In Phase Four, personnel will summarize all work done for the study, emphasizing management concepts and implications of pertinent State legislation concerning viable alternatives for debris disposal.

Approach

Research personnel reviewed clearing contracts of numerous dam sites in different physiographic regions of the United States, visiting several dam sites and talking with COE contract administrators and planning, construction, and operations personnel. They contacted major equipment dealers and manufacturers to discuss what equipment was available for clearing operations, and reviewed current literature regarding clearing operations.

From this information, a list of evaluation factors was prepared which will assist in selection of clearing and disposal methods. Additional attention was given to such pertinent items as comparing clearing and cleaning operations and items relating to contract specifications.

2 CURRENT CLEARING METHODS

Types of Clearing

Two types of vegetation are considered in most clearing contracts: brush and trees. *Brush* is usually defined as woody growth less than 2 in. (5.08 cm) in diameter, measured 6 in. (15.24 cm) from the ground on the uphill side; and less than 6 ft (1.83 m) high, measured from the ground on the uphill side. *Trees* are normally considered to be woody growth not falling within the limits of brush as defined above.[4]

Several sites in a project area may require different types of clearing. The basic determinant for the intensity of a clearing operation is the cleared site's final use. Other considerations include clearing costs, maintenance and maintenance costs, environmental protection, and safety.

Several basic types of clearing are used at impoundments, including but not limited to the following:

1. Modified Clearing (Topping). Vegetation on the floodplain and adjacent slopes is cut at a specified height above ground level rather than at the base of the stem near ground level. The exact height should be stipulated in the contract. Topping is used in areas where the minimum depth of the conservation or permanent pool will be several feet above the top of the cut stems and the vegetation will not present a hazard or inhibit construction or operation activities.

2. Complete Clearing (Clear Cutting). The vegetation is cut near the base of the stem, leaving a low stump in the ground. Normally this type of clearing implies that all vegetation will be removed at just above ground level. The height of acceptable stumpage should be stipulated in the contract. Clear cutting is used in areas where the permanent pool may be relatively shallow but the stumpage will not present a hazard or inhibit activities.

3. Clear Cutting and Grubbing. Individual plants or groups of plants at a specific site are selected for complete removal by clear cutting and grubbing. The vegetation is cut off near ground level, and the stumps are removed. Another method uses heavy equipment to uproot the entire plant without separating the stem from the root system. Clear cutting and grubbing remove all trees and stumps that might present a hazard or inhibit construction or operation activities.

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[4] *Clearing, Guide Specifications--Civil Works Construction*, CE 1301, (Department of the Army, Corps of Engineers, Office of the Chief of Engineers, September 1969), p 2.

4. Selective Cutting. Selective cutting is similar to clear cutting, but leaves individual plants or groups of plants in specified areas of the site.

The degree of clearing at a site is determined by personnel at the respective COE District and/or Division office. (Engineering Regulation (ER) 415-2-1, *Construction, Policies and Practices--Clearing*, provides general information; see Appendix B.)

Factors to Consider When Selecting Clearing Method(s)

Many factors affect clearing operations; however, data and experience concerning how a certain factor will increase or decrease production and costs are insufficient. Each clearing project is different and cannot be compared directly to another.

Four main categories of factors warrant careful consideration: job specifications, physical, legal-environmental, and vegetation.

Job Specifications

Completion Date (Time). This element affects clearing method selection, since while one method may be more productive than another, it may have other disadvantages related directly to a specific site. Personnel may have to evaluate the advantage of increased production compared to such disadvantages as increased costs, increased erosion problems, or additional processing to dispose of the vegetation.

Land Use. The clearing methods should be evaluated to determine which method will best leave the cleared site ready for the next stage of development. Selecting an inefficient method may require additional work to prepare the area for the end use and thus increase total costs of the site development.

If the site requires extensive work after the clearing operation, such as placement of fill material, a less complete method of clearing may be used to reduce clearing costs.

Method of Disposal. There are several methods to dispose of cleared vegetation (see Chapter 3). Disposing of cleared vegetation can be expensive, and the selection of an appropriate clearing method that can partially or totally prepare the vegetation for disposal can reduce disposal costs.

Logging and other salvage operations should not be done while clearing operations are being performed, since both operations cannot be accomplished effectively at the same time.

Size of the Project Area. The size of the project area influences the selection of a clearing method. For example, it would not be economically feasible to acquire several pieces of large, mechanized clearing equipment to clear a small site; on the other hand, a small work force with a minimum of equipment may not be able to clear a large area by the completion date.

Physical Factors

Terrain. Large, mechanized clearing equipment works best on flat, well-drained land. Steep slopes, rock outcrops, wet areas, or highly eroded, gullied land reduce the effectiveness of mechanized clearing equipment and restrict the accessibility of man, vehicles, and equipment. Large-scale, topographic maps from the U.S. Geological Survey used with current aerial photographs can supply information regarding a project area's terrain.

Soils. The coarse texture of sandy soils often facilitates the use of mechanized equipment. Sandy soils are usually better drained than clay or silt soils. Stumps and tree roots can normally be removed more easily from sandy soils than from clay or silt soils which can become compacted and hard.

Several factors determine how wet or dry a soil will be, including water table depth, density of vegetative cover, soil type and texture, and climatic conditions.

Conditions for accessibility are favorable when traction and slope do not hinder equipment and vehicles after repeated passes in the same tracks. Soft conditions exist when more than one or two passes over the same track moderately or severely hamper the performance of equipment or vehicles. Poor conditions exist when the first pass is difficult or uncertain.

Soil maps from the local Soil Conservation Service office and current aerial photographs can provide information about soil conditions.

Climate. Project area climate will determine when men and equipment can work on the clearing operation. Certain climatic conditions will be more conducive for outdoor work and actually assist in the clearing operations. Dry periods are better for vehicle and equipment mobility. Cold temperatures freeze the soil and reduce erosion. Wet and marshy areas are frozen over during cold periods, which may improve the mobility of equipment and vehicles.

Other climatic conditions can inhibit clearing operations. During wet periods, cleared areas are more subject to erosion, and flooding may float cleared vegetation downstream into the dam site and other areas. Denser vegetation and foliage associated with warm weather can reduce visibility. Clearing operations can cause forest fires during dry periods.

Climatic information can be obtained from the National Climatic Center, National Weather Service, and from state agencies such as water and geological surveys.

Legal-Environmental

New state and local environmental laws may prohibit the use of some clearing methods. The laws, intended to improve environmental quality, may be concerned with noise, soil conservation, stream quality, air quality, and preservation of wildlife.

All regulating agencies should be contacted before selection of a clearing method to insure compliance with state and local ordinances. The regulating agencies will often permit the use of a prohibited clearing method if it can be proved that there is no alternative. These permits usually restrict periods of operation.

Vegetation

Several vegetation factors affect land-clearing operations.

Tree Count. Tree density affects the production and costs of a clearing operation. An area having a high tree density will usually require more clearing time than a similar area having a low tree density, even though the same clearing method is used. A large tree density affects the mobility of men, vehicles, and equipment. Tree density varies by site; one site may have a tree density suitable for a particular clearing method, but other sites in the project area may not have the tree density to support the operating costs of this clearing method. A site's tree density should be evaluated to determine the best method(s) for the entire project area.

Tree Size. Tree size also affects a clearing operation's production costs. Large trees will require larger pieces of equipment to fell and move them. Normally, large trees have larger and more extensive root systems, which will inhibit clearing and grubbing operations. Tree size is also an important marketing consideration, since it is not economically worthwhile to harvest small trees containing small amounts of wood.

Tree Types. The type of trees affects the production and costs of a clearing operation. Some trees have shallow root systems, which are associated with a high water table. Others have deep tap-roots which may hinder clearing and grubbing operations. Some species are more apt to produce sprouting and regrowth from a cut stump than others. Where permissible, herbicides which affect the root system of stumps can be used to prevent regrowth.

Type of vegetation is another important marketability factor. Certain tree species have a higher market value per unit volume than

others. The additional costs of segregating the logs which have a high value per unit volume may be more than offset by their selling price.

Vines and Brush. Vines and brush hamper the mobility of men, vehicles, and equipment. It may be economically feasible to remove some of this vegetation to improve accessibility to an area. It is more difficult to handle and remove brush and vines from an area than trees. Brush and vines should be disposed of as close to the clearing site as possible to avoid additional costs associated with the difficulties of handling and transporting them.

Vegetative Cover Survey

A survey should be conducted in the project area to determine the vegetative cover of the different sites. Several methods for analyzing vegetative cover can be found in forestry textbooks. One simple method is to run one or more transect lines for a distance of at least 328 ft (100 m) through representative area(s) of each site. (Aerial photographs can be used to determine representative areas and the approximate positions to locate the transect lines.) When the transect line(s) has been determined, personnel can conduct a "cruise" at approximately 16 ft (5 m) on each side of the line to record the number of trees, their diameters, species, and root systems, as well as comments regarding brush and vines. The sample of 328 ft (100 m) by 32 ft (10 m) covers about 1/4 acre (1/10 hectare).

Figure 1 is a sample form for recording vegetative information. An area's physical factors can also be noted during this survey.

The information obtained by the survey can be used to determine the best method(s) for clearing the project area. The vegetative survey will also contain the information necessary to evaluate the marketability of the trees.

Methods for Clearing Vegetation (Felling and Moving)

Several methods can be used to clear vegetation at impoundments. Researchers have established two main categories of clearing methods: manual and mechanical (heavy equipment).

Manual

This method uses a group of workers on foot, with hand tools to clear the vegetation. The hand tools vary in complexity from axes to power chain saws.

In the past, using axes and hand saws usually limited individual production, although in some situations, this procedure may be advantageous.

Diameters

Species	2-6 in. (5.08-15.24 cm)	6 in.-1 ft (15.24-30.48 cm)	1-2 ft (.30-.61 m)	2-3 ft (.61-.91 m)	3-4 ft (.91-1.21 m)	4-6 ft (1.21-1.83 m)	Greater than 6 ft 1.83 m)
Comments: root systems							
Vines							

Figure 1. Sample form for recording vegetative information.

In recent years, a worker's production has been increased considerably by the development of lightweight power chain saws. Several companies produce models with a variety of options.

The capital investment and operating costs associated with the use of lightweight power chain saws are more than offset by a worker's increased production.

There are several advantages to using the manual method with power chain saws: (1) the operating costs and capital investment are small in comparison to that of large pieces of mechanized equipment such as dozers; (2) wages for power chain saw operators are normally less than those for heavy equipment operators; (3) a man with a lightweight power chain saw can traverse many terrain features that are inaccessible to heavy equipment.

There is one major disadvantage to the manual method: when the vegetation has been cut down, the size and amount of vegetation that the workers can move is limited. If the vegetation is brush that can be disposed of on or near the site, handling and transportation may not be a problem. But if the cut vegetation consists of large trees that must be removed, handling and transportation can be a major problem.

The manual method is primarily used for topping, clear cutting, and selective cutting.

Mechanical (Heavy Equipment)

There are numerous mechanical methods for clearing vegetation from the land. Several manufacturers produce heavy equipment and tools designed specifically for clearing operations.

Researchers have divided mechanical land clearing into three basic methods by type of operation: (1) uprooting, (2) shearing, and (3) chopping.

Uprooting the Vegetation. Many types of heavy equipment and tools can be used to uproot vegetation.

In the past, mechanical land-clearing activities were modifications of earthmoving techniques. The standard crawler tractor with the ordinary straight or angled blade (Figure 2) was used to clear land. There are several disadvantages to using the ordinary bulldozer blade. It is not an efficient land-clearing tool. If a large tree cannot be pushed over, it must be dug out of the ground, which is a time-consuming, costly operation. The blade will either pass over small trees and brush and bend them over or it will break them off, leaving small stumps which may have to be removed later. A dozer blade is not suitable for piling trees and brush because it moves too much soil with the vegetation.

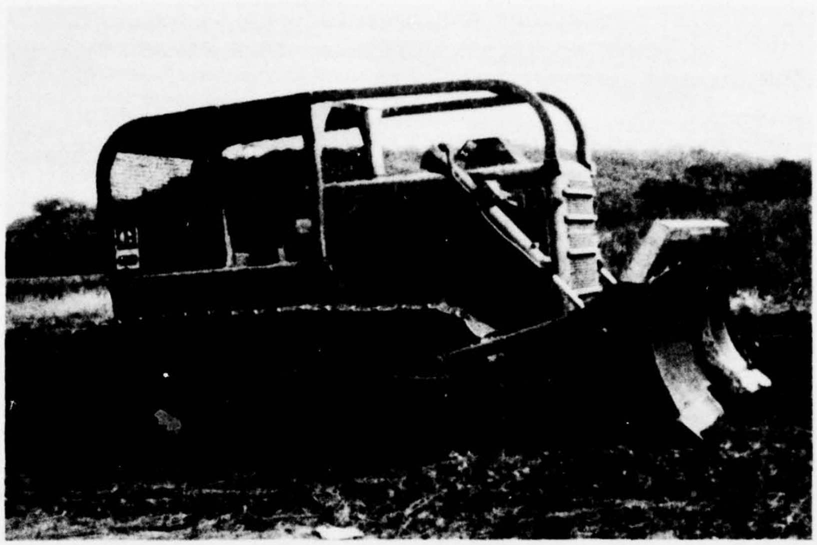

Figure 2. Standard crawler tractor with bulldozer blade.

Heavy equipment manufacturers and users have proved that more land can be cleared in a specified time if the crawler tractors are equipped with specialized land-clearing tools, one of which is a rake. A variety of rakes can be attached to crawler tractors for clearing vegetation and rocks. Figure 3 shows a multi-application rake being used to clear vegetation. As a rake passes through the soil, it rips and pushes the vegetation, but the soil passes between its teeth. Rakes work best in dry sandy soil; if the soil is wet or has a high clay content, it may pack between the teeth, as illustrated in Figure 4. When this happens, the rake is, in effect, a bulldozer blade, with all of its disadvantages in land-clearing operations.

A clamp rake's clamps (Figure 5) can be closed down to hold vegetation against the rake. This type of rake is recommended for raking, piling, or moving vegetation, but not for grubbing.

Several rakes have been designed for specific clearing operations, including many that can be mounted on wheeled equipment.

Figure 6 illustrates a tree pusher, which can add leverage to the force a tractor applies when uprooting a tree. Tree pushers work best on medium-sized trees of 12 to 24 in. (30.48 to 60.96 cm) diameter. A

Figure 3. Multi-application rake.

Figure 4. Multi-application rake
(note soil packed between teeth).

Figure 5. Clamp rake (note two clamps mounted on top of the rake).

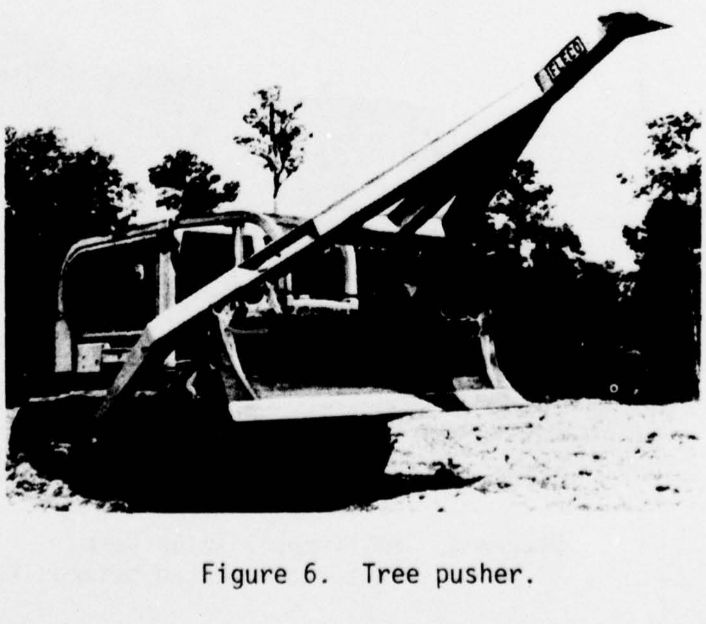

Figure 6. Tree pusher.

root cutter can be used around larger trees to increase the effectiveness of the tree pusher. It is uneconomical to use tree pushers on small trees and brush that do not require the additional leverage of the knockdown beam.

Shearing the Vegetation. Two basic angle shearing blades are manufactured today. One type has a stinger and straight cutting edge, as illustrated in Figure 7. The other type is "V"-shaped, with a wedge-shaped splitter, as illustrated in Figure 8.

Figure 7. Stinger and straight-edge shearing blade.

Land clearing with a shear blade applies the total horsepower of the crawler tractor to the cutting edge of the shear blade to cut all vegetative growth at ground level.

The stinger or splitter splits large trees in one or more passes; the shearing blade then fells the tree with the cutting edge. The stinger increases the tree size that a given tractor can fell with a shear blade.

Both types of shear blades work best in areas that are relatively flat and have heavy, stone-free types of loam and clay soils.

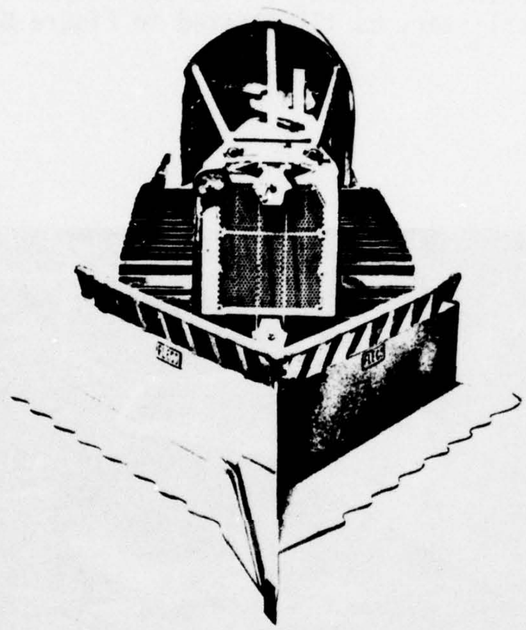

Figure 8. "V"-shaped shear blade with splitter.

A second operation removes the stumps and roots left in the ground by the shearing operation. Either the straight-edge shearing blade can be used to remove the stumps and roots, or a rake can be used to grub the roots and stumps out.

Figure 9 illustrates a tree shear, which can be used to cut trees. Its hydraulic cutting action is limited by tree size and composition. It was primarily designed to cut trees for pulpwood and is uneconomical for cutting brush or vines. Since the tree shear cuts vegetation at ground level, a second operation must be performed to remove stumps and roots.

Tree shears may also be attached to boats and barges for topping vegetation after the impoundment has been partially filled.

<u>Chopping the Vegetation</u>. Figure 10 shows a single unit of a roller chopper; as many as three units may be pulled by a crawler tractor. The

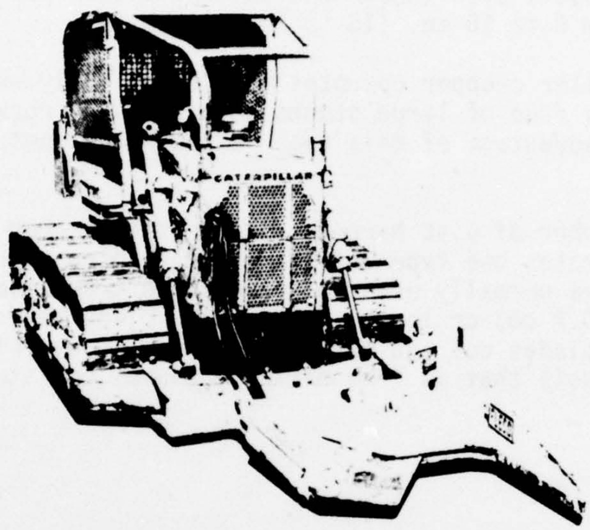

Figure 9. Tree shear.

Figure 10. Single-unit roller chopper.

cutting blades, welded to the drum of the chopper, cut and fracture vegetative growth. The drum of the chopper is normally filled with water to increase weight. There is a minimum amount of disturbance to the topsoil even though the cutting blades penetrate the soil crust from 6 to 10 in. (15 to 25 cm).

A roller chopper operates most efficiently when the soil is relatively free of large stones and stumps or rock outcrops. The major disadvantage of this tool is that it cannot chop large-diameter trees.

A number of disc harrows can be used to chop vegetation. Figure 11 illustrates one type which is used to plow under light brush. Disc harrows are normally used in areas where tree diameters are 3 to 4 in. (7.6 to 10.2 cm) or less. The tractor blade bends the vegetation, and the disc blades cut and bury it. Effective use of a disc harrow requires soil that is free of large stones and stumps.

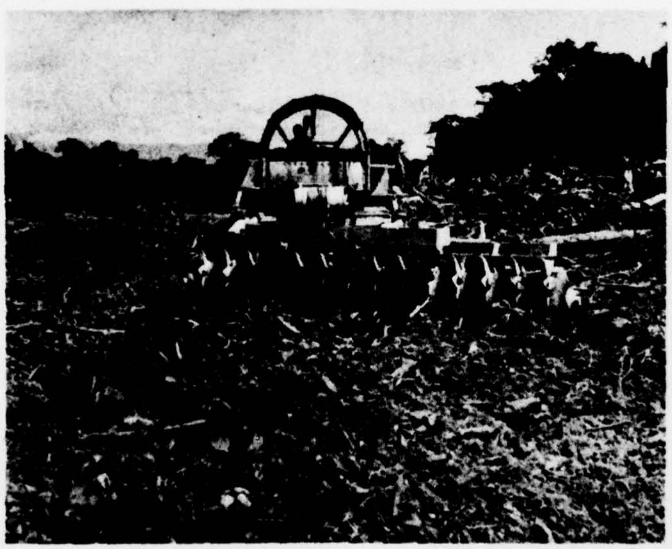

Figure 11. Offset disc harrow.

Disc harrows turn and greatly disturb the soil surface when they bury the vegetation. This can be advantageous when a new type of vegetation will be established in the area after the clearing operation; however, it may create erosion problems if no vegetative cover is established.

Most of the heavy equipment and tools discussed in this section require a large capital investment, and the hourly operating costs for this equipment can be considerable.

Methods for Moving Felled Vegetation

Workers can move brush, vines, and small trees short distances, but it is not economically feasible for them to cut medium and large trees into movable pieces.

Horses and mules have been used in logging operations to "twitch" logs out of the woods. This method does not disturb the forest litter as much as mechanical methods, thus avoiding creation of conditions that may lead to erosion before the impoundment is filled. However, draft animals are not available in most areas of the United States and, if they were, the operation would be very time-consuming. If the personnel and animals were available, this method would be ideal for moving selectively cut trees through sites having delicate ecological balances, i.e., nature study areas and the like.

Another formerly used method for removing felled vegetation was cutting the vegetation during a low-water period and letting flood waters float the vegetation downstream out of the area.

A variation of this method is used today in certain areas where access to removing felled vegetation is limited. The vegetation is cut before filling the impoundment, and the rising waters of the impoundment float it out of the area. This method works well in areas having steep slopes and large trees.

One problem associated with this method is lack of control over the vegetation. Log booms can be used to encircle it and move it to an area for removal for disposal; however, some of it may float away and impede some beneficial uses of the impoundment.

Several pieces of heavy equipment and tools have been designed for handling and removing felled vegetation.

There are several models of rakes for wheeled and tracked equipment. Many manufacturers produce wheeled equipment which is designed to skid logs out of an area. This equipment can be used in fairly rugged areas having limited access.

In very steep and rugged terrain, where there is no access for any type of wheeled or tracked equipment, winches have been established near accessible areas and long cables used to drag felled vegetation out of the cut area.

All the mechanical methods mentioned above disturb the forest floor and can promote erosion.

Costs of Clearing Methods

Manual

The production rate of a manual clearing operation depends on tree size, type and density, accessibility, the physical condition of the workers, etc. The number of variables involved makes it difficult to determine the production rate and costs for this clearing method.

The capital investment for the cutting equipment required for a manual clearing operation is low compared to that for heavy equipment. Several models of specialized power chain saws are available for clearing different sizes of vegetation. The model determines the purchase price, which starts at approximately $100.

Operating costs for manual clearing equipment are low compared to those of heavy equipment. Fuel consumption is much less, and the costs for preventive maintenance and repair are much lower for a power saw. One main advantage of manual clearing is minimization of terrain (grade) effect on clearing rate.

In flat terrain, the production capabilities of heavy equipment are appreciably higher. Production from manually operated cutting equipment will increase in flat terrain, but not in the same proportion as when heavy equipment is used. Portions of the project may include variables that make the use of heavy equipment economically feasible; in other portions, manual clearing may be the only economically viable means of clearing the vegetation.

Mechanical (Heavy Equipment)

Heavy equipment manufacturers and users have conducted tests to determine the production capacity and costs for various clearing operations.

The many variables make it extremely difficult to accurately estimate the total and individual unit production and the cost per unit area of a land-clearing operation.

For example, the following formula and production table were developed by Rome Plow Company for determining the cutting time per acre (in minutes) for a crawler tractor equipped with a shear blade.[5]

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[5] *Effective Methods of Land Clearing* (Caterpillar Tractor Company), pp 28-29.

$$T = B + M_1N_1 + M_2N_2 + M_3N_3 + M_4N_4 + DF$$

where T = Time per acre in minutes
B = Base time for each tractor per acre
M = Minutes per tree in each diameter range
N = Number of trees per acre in each diameter range obtained from field cruise
D = Sum of diameter in feet of all trees per acre over 6 ft (1.83 m) in diameter at ground level obtained from field cruise
F = Minutes per foot of diameter for trees of more than 6 ft (1.83 m) in diameter.

To estimate the cutting time per acre on a specific clearing job, apply the factors shown in Table 1 and the data from a vegetative survey of the site (described earlier) to the above formula.

The following factors should also be applied to the formula and table where applicable:

1. The presence of hardwoods:
   75 to 100 percent: Add 30 percent to total time (T)
   25 to 75 percent: No change
   0 to 25 percent: Subtract 30 percent from total time (T)

2. Density of vegetation less than 12 in. (.30 m) in diameter:
   Dense (600 trees/acre [.41 hectare]): Add 100 percent to base time (B)
   Medium (400 to 600 trees/acre [.41 hectare]): No change
   Light (less than 400 trees/acre [.41 hectare]): Subtract 30 percent from total time (T)

3. Presence of heavy vines:
   Add 100 percent to base time (B)

The formula is not entirely accurate because of the variables that increase or decrease production.

Similar formulas and tables have been prepared to estimate the production of heavy equipment and tools for other clearing operations, such as stumping and chopping.

After it has been estimated how long each piece of heavy equipment will be used to perform the clearing operation, the average operating cost per hour can be multiplied by the total number of hours to estimate the total cost for using the piece of equipment at the project. The average operating cost per hour varies by piece of equipment; it is available from most dealers and includes fuel, normal maintenance, and depreciation costs. Labor costs vary nationwide and must also be included.

Table 1

Production Table for Cutting

Caterpillar[1] Tractor	Base[2] Minutes (B)	Dia. Range[3] 1-2 ft (.30-.61 m) M_1	Dia. Range 2-3 ft (.61-.91 m) M_2	Dia. Range 3-4 ft (.91-.21 m) M_3	Dia. Range 4-6 ft (1.21-1.83 m) M_4	For Dia. Over[4] 6 ft (1.83 m) per foot (.30 m) (F)
D9G	18	0.2	0.5	1.5	4	1.2
D8H	21	0.3	1.5	2.5	7	1.2
D7E	28	0.5	2.0	4.0	12	4
D6C	40	0.8	4.0	8.0	25	---

[1] Based on current-model tractors working on reasonable level terrain (below 10 percent grade) with good footing and no stones in an average mixture of soft and hard woods. Tractor should be in proper operating condition and have a sharp shear blade. (Caterpillar is registered trademark of Caterpillar Tractor Co.)

[2] The base figures represent the number of minutes required for each tractor to cover an acre (.41 hectare) of light material where no trees require splitting or other individual treatment.

[3] M_1 represents the minutes required to cut trees from 1 to 2 ft (.30 to .61 m) in diameter at ground level. M_2 is the factor for trees in the 2 to 3 ft (.61 to .91 m) diameter range. M_3 is the factor for trees in the 3 to 4 ft (.91 to 1.21 m) diameter range. M_4 is the factor for trees in the 4 to 6 ft (1.21-1.83 m) diameter range.

[4] The figures in this column represent the number of minutes required per foot (.30 m) of tree diameter for each tractor to cut trees of more than 6 ft (1.83 m) in diameter.

The completion date (time factor) is important because it determines the amount and production capacity of heavy equipment needed to complete the job in the required time. After estimating the production and costs of various machines and tools at specific sites, COE personnel and contractors can best estimate which equipment to use to minimize a project's clearing costs.

It should be noted that the information in the table developed by Rome Plow Company was very specific about grade, tree density and type, tractor operating conditions, footing, etc. Steeper slopes, rocky soil, poor footing, and variations in tree density and type will affect the production times given in the table. Some of these variables can be accounted for, but their influence is hard to predict and will affect the project's production time and costs.

Contractors working on another phase of a dam project may be awarded clearing contracts. These contractors can usually attach different tools to heavy equipment they already have in the area and make it suitable for clearing operations.

On-Site Activities

Both manual and mechanical clearing methods were used at all sites visited by the investigators. Clear cutting was the main clearing type used. Men equipped with power chain saws felled the vegetation, and heavy equipment, primarily crawler tractors with rake attachments, was used to move the vegetation. Heavy equipment was used to fell and move the vegetation at several sites where small areas required clear cutting and grubbing.

The sites and the contracts at the visited projects were not large enough to support a large-scale mechanical clearing operation. In most cases, the terrain was not level enough to provide access to heavy equipment when clearing was necessary.

At most sites, the floodplains were flat and had been farmed; trees were scattered and located in fence rows or along streams. Although these flat areas would be ideal for large-scale mechanical clearing operations, there were not many trees. The clearing operations were being conducted on slopes adjacent to the floodplain where there were no farming operations and vegetative growth was dense; however, these areas were not suitable for large-scale mechanical clearing operations. Large-scale excavation would have been necessary to permit access of heavy equipment into some of these areas. Elsewhere, heavy equipment was used to create access roads so the felled vegetation could be moved to the disposal areas.

Most vegetation was disposed of near the area where it was cut. This reduced the costs associated with handling and transporting the vegetation. Some salvage operations were being conducted at several sites prior to the clearing operations.

3 CURRENT DISPOSAL METHODS

Four main categories of cut vegetation disposal techniques evolved during the study: burying, burning, selling, and using at the project site.

Burying the Vegetation

Cut vegetation can be buried in two forms: processed and unprocessed. Processing increases the density of vegetation per unit of disposal site that the vegetation will occupy in the burial area. Chipping is the best form of processing because it reduces all the vegetation to a small, relatively uniform size, which facilitates handling and burial. Trimming is another type of processing. If limbs are trimmed from the stems of trees and the vegetative material is stacked instead of being piled, it will take up less space at the disposal site.

Both types of processing allow the vegetative material to be more closely compacted as it is being buried. Normally, the cover material placed over processed vegetation will settle less than that placed over unprocessed material because there are fewer voids in the processed material.

Processing the cut vegetation increases the cost of the clearing operation; however, some public and private landfills will not accept large quantities of vegetative debris unless it is processed.

Vegetative debris should be buried as close as possible to the cutting site to minimize handling and transportation costs. Figure 12 shows the bank of a stream at a dam project where chain saws were used to clear-cut the vegetation. The burial site for the debris was approximately 50 yd (45.7 m) to the right of the stream bank (see Figure 13). Handling and transportation costs were minimized because the disposal site was located near the cutting area. The vegetative material was not processed before it was buried. A crawler tractor with a bulldozer blade was used to excavate the hole, move the debris, and place the cover material.

Burning the Vegetation

Two types of burning operations can be used to dispose of cleared vegetation: confined and unconfined (open) burning. Confined burning is an attempt to control pollution emissions. The material to be burned is placed in an enclosed pit or chamber so the burning can be controlled.

Normally, no attempt is made to control pollutant emission during unconfined burning. The material is placed on the ground and set on fire; since the material is not placed in an enclosure, it is difficult

Figure 12. Cleared area at a project.

Figure 13. Burial site for unprocessed debris.

to control the burning. Occasionally, large fans assist the combustion; this practice may reduce the emission of some pollutants, but no means have been developed to measure the results.

Several states have prohibited unconfined burning of vegetative debris, although most have approved the use of open-pit incinerators.

Open-pit incineration does not guarantee compliance with pollution codes for two reasons: (1) it is not possible to specify or predict what extraneous wastes will be burned with vegetative debris, and (2) there is no way to reliably measure emissions from this type of unit.

Some states require that operators obtain permits before beginning the burning operations and may periodically inspect operations for compliance with the specific operating procedure.

Three components are necessary for open-pit incineration: the pit, the loading or charging equipment, and the air source (blower).

Several types of pits can be used. An earth pit (Figure 14) may provide a satisfactory temporary enclosure if the water table depth and the soil are conducive to the excavation. Figure 15 shows how a standard 40-ft (12.2 m) railroad boxcar was used for the enclosure. Railroad boxcars provide a more stable pit wall and prevent earth from caving into the pit. An air space, 1 to 2 ft (.30 to .61 m) wide, is required between the sides of the boxcar and the earth pit to allow the heat to dissipate and prevent the sides of the boxcar from buckling.

A more permanent pit can be constructed by placing precast refractory concrete tiles on a metal frame, as illustrated in Figure 16. The tiles can be replaced individually if they break, and the entire pit can be disassembled and moved.

Earth pits have been lined with refractory concrete and used to burn vegetative debris, but these are permanent and cannot be relocated.

The type of equipment used to charge the pit depends on the size and type of pit, pit location, debris location, debris size, and total volume of debris.

Cranes with clamshell buckets are considered to be the safest and most efficient equipment for charging pits at large-scale burning operations. They are the best equipment for handling root wads and can also be used for cleaning ash out of a pit. One crane can be used to charge and clean several pits at a large-scale burning operation.

Front-end loaders can also be used to charge and clean pits. They should charge subsurface pits from behind the air source rather than from the open side to prevent the equipment from falling into the pit and to prevent debris from being dumped onto the air source.

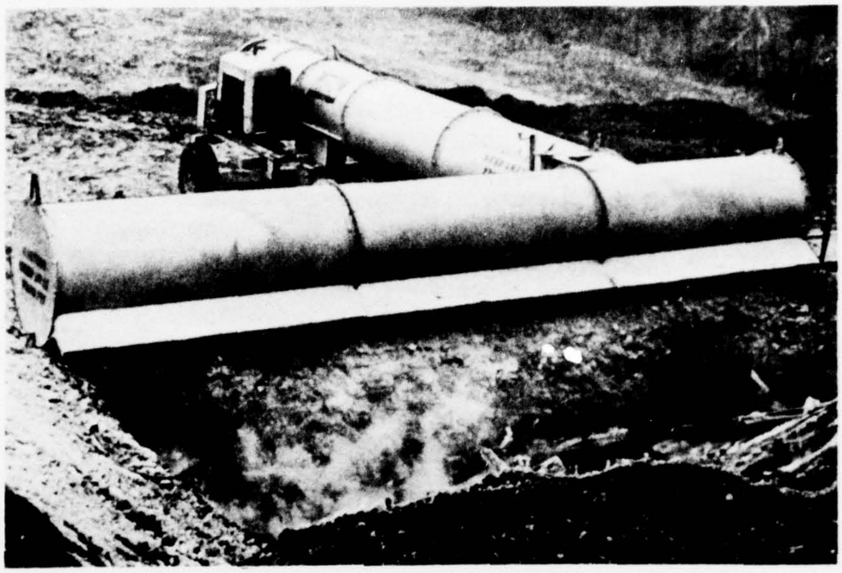

Figure 14. Earth pit for pit incineration.

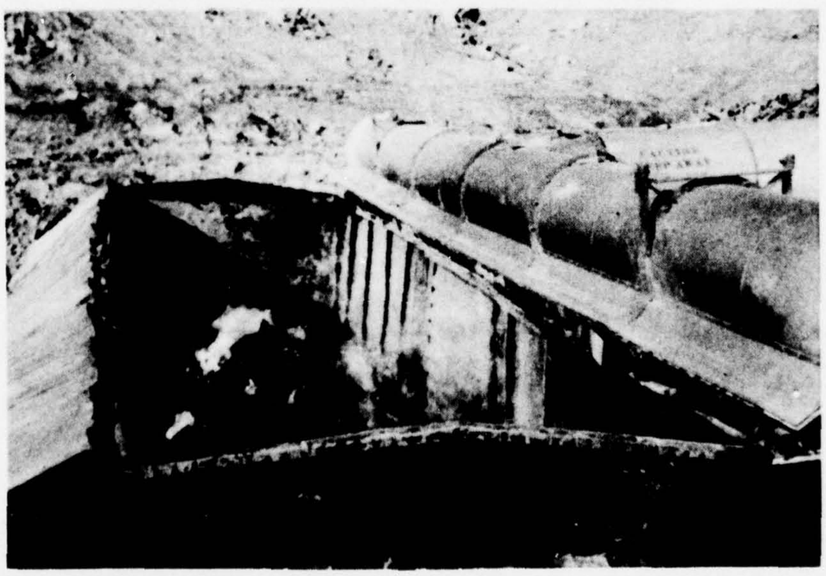

Figure 15. Railroad boxcar used as a pit.

Crawler tractors with bulldozer blades can be used to charge subsurface pits. The blade can be used to push debris into the pit from the open side. Usually considerable dirt is moved with the debris into the pit. This may produce smoke and will reduce the pit's life span.

Several U.S. companies manufacture portable and stationary air sources (blowers). (Three models were depicted in Figures 14, 15, and 16.). Blowers are manufactured in several different lengths, which will determine the pit length. Normally, as pit size increases, production also increases. The burning rate also depends on the type and size of the vegetative debris and the wood's moisture content. Figure 17 illustrates the dimensions for pit excavation and blower location at a site prepared for open-pit incineration. The configuration of the pit is important for the air curtain to work properly.

Selling the Vegetation

Vegetative material may be sold by the clearing contractor in either unprocessed and processed form. Unprocessed vegetation (including brush and trees) is sold in its natural state or is cut and removed from the original site. The purchaser may then process the vegetation for lumber, posts, firewood, or chips.

Figure 18 shows the vegetation cut at a site by the clearing contractor. Sawmill personnel selected the logs they could use (see Figure 19), and the remainder was piled (Figure 20) and open-burned (Figure 21). The State Department of Environmental Resources permitted the contractor to dispose of the vegetation by unconfined burning, but the activities had to be coordinated with the State Forest Service. Open-burning operations could only be conducted when forest and weather conditions were appropriate.

At another site, the vegetation was cleared by a clearing contractor. Figure 22 shows the floodplain during and after the clearing activities. Much of the cleared vegetation was chipped by the contractor for the State Highway Department and stored in piles near the location where it would be used, illustrated in Figure 23. Later the chips were spread on the slopes adjacent to the relocated state highway, as shown in Figure 24. Figure 25 shows the chips being used on a steeper slope at another highway location. The wood chips were spread on the exposed soil of the slopes to reduce the effect of wind and water erosion until vegetation could be established. The approximate size of the wood chips can be determined in Figure 26, where they are compared to two U.S. coins (quarters).

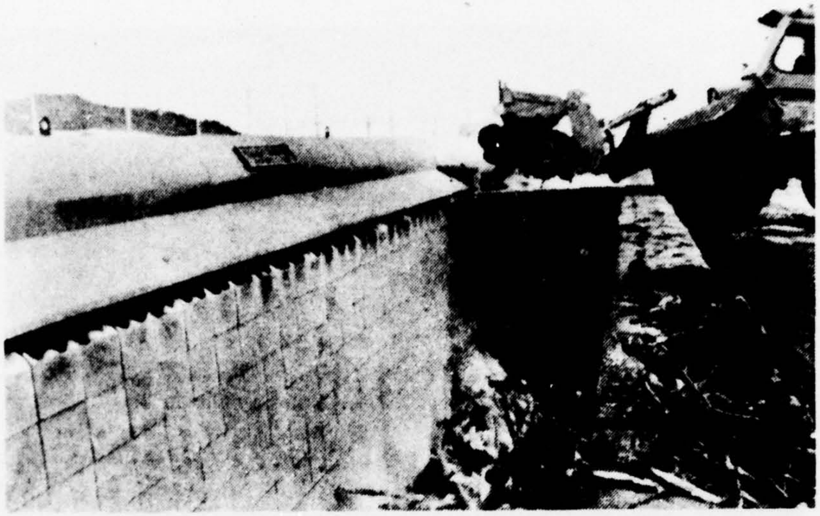

Figure 16. Pit lined by refractory concrete tile on metal frame.

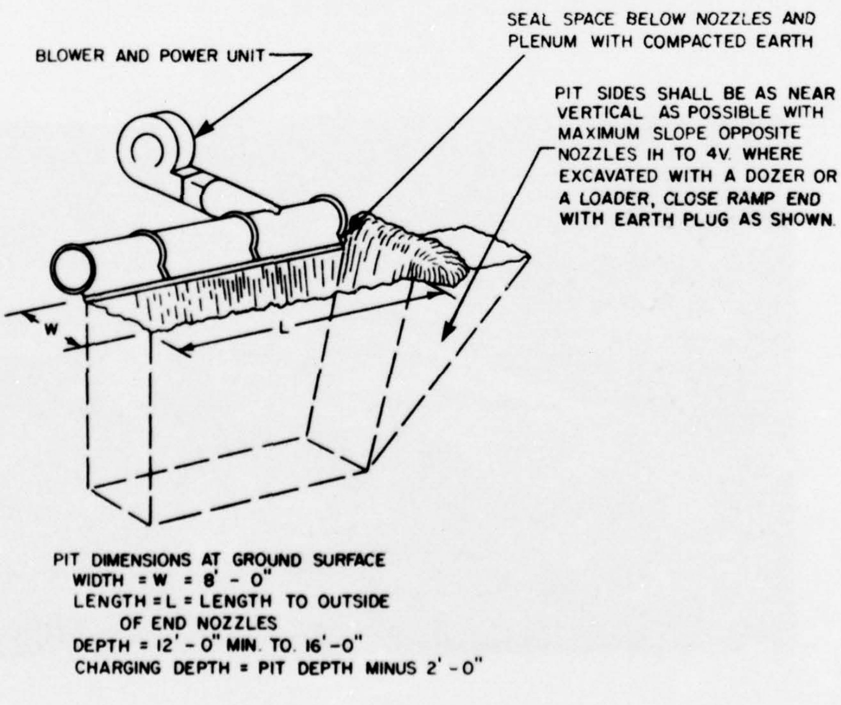

Figure 17. Open-pit incinerator.

Figure 18. Vegetation cut by a clearing contractor.

Figure 19. Selected logs.

Figure 20. Vegetation piled for burning.

Figure 21. Open burning--permission was granted by state regulating agency.

Figure 22. Floodplains during and after clearing operations.

Figure 23. Piles of stored wood chips.

Figure 24. Chips placed on exposed slopes of relocated state highway.

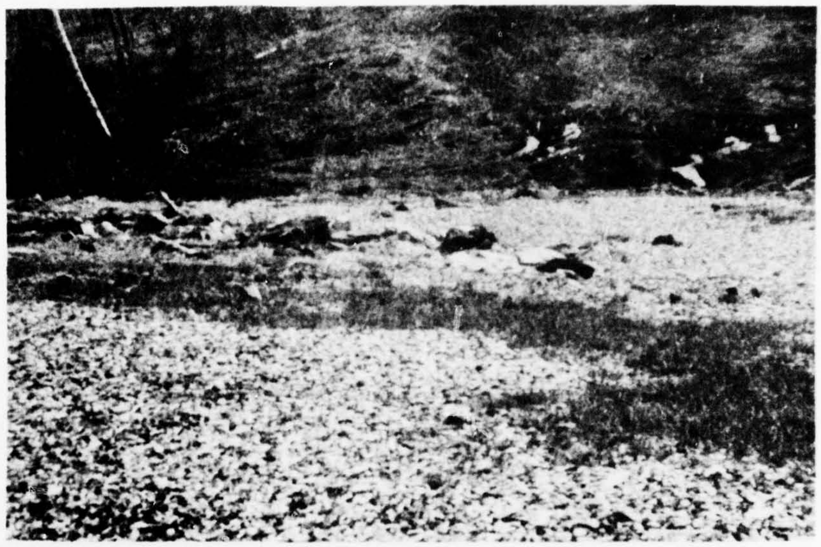

Figure 25. Chips placed on steep slope of relocated state highway.

Figure 26. Size of the wood chips as compared to two quarters.

Using Cut Vegetation at the Project

Cut vegetation may be used for *wildlife habitat* in the project area. After the vegetation has been cut, it can be moved to areas above the high water level of the flood pool where it can be piled and provide cover for wildlife. Care should be taken to prevent the material from washing into the impoundment; the material should be positioned or anchored to prevent it from moving.

Cut vegetation can also be used to establish *fish habitats* in the impoundment. Figure 27 shows a boat passage cut through a woods paralleling a stream at a project. Since the area will be inundated by

Figure 27. Boat passage cut through woods.

the rising waters of the impoundment, the trees removed for the boat passage were used to construct several fish habitats. Figure 28 illustrates one of the fish habitats. Figure 29 shows a closeup of an anchoring line, and Figure 30 illustrates the specifications used to construct the fish habitat.

The cleared vegetation can be used to provide *firewood* at camping sites in the project area; it can be piled in an area close to the camp sites. The clearing contract can provide cut firewood for campsites by stipulating that the clearing contractor provide a specified amount of firewood at each campsite.

Figure 28. Fish habitat.

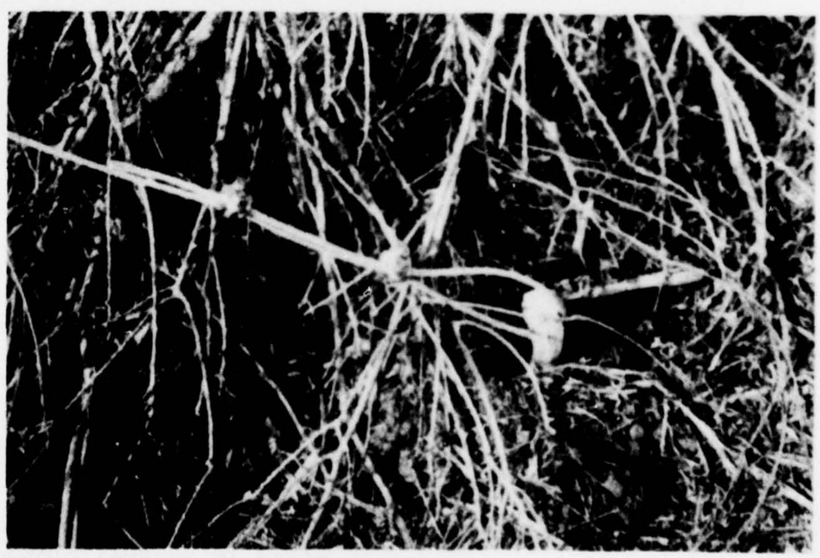

Figure 29. Anchoring line for fish habitat.

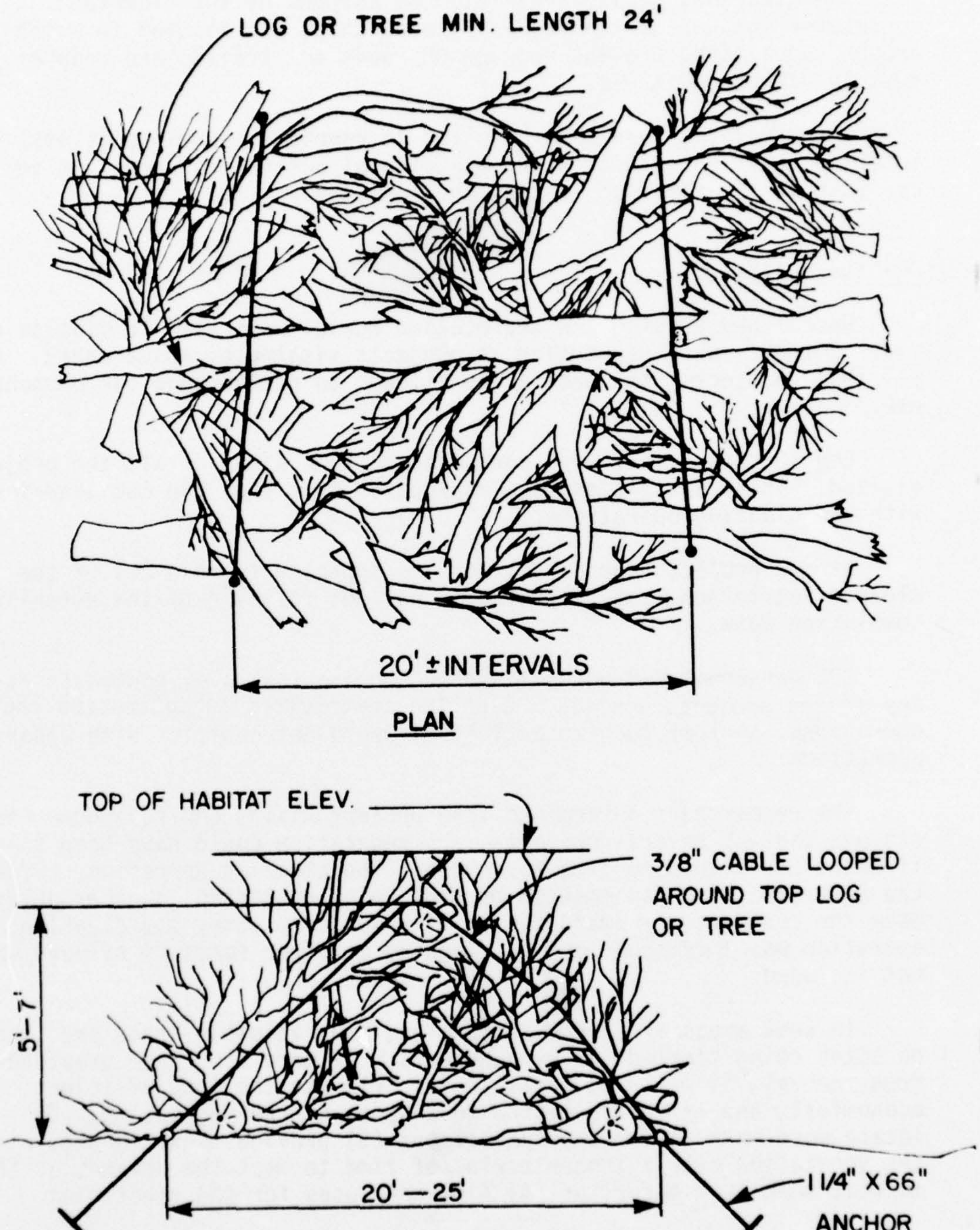

Figure 30. Typical timber fish habitat. (Metric conversion factors: 1 in. = 2.54 cm; 1 ft =.3 m).

The cleared vegetation can also be chipped by the clearing contractor *for use at the project.* Wood chips can be used to mulch around vegetation, prevent erosion on roads and trails, and reduce dust in playground areas.

Cut vegetation can also be piled in remote areas where it will not interfere with construction and operational activities where the public can take it for firewood, posts, and home use.

On-Site Activities

Unconfined burning and unprocessed burial were used to dispose of most of the cleared vegetation at projects visited by researchers. At all these projects, the public was allowed to remove wood for personal use.

Logging operations were conducted on some sites at all the projects visited. These activities were managed so that they did not interfere with the clearing operations.

At one project, the contractor was supposed to chip all of the cleared vegetation, but he proved it was not feasible by the established completion date.

COE personnel did not administer logging (salvage) contracts at any of the projects visited. Clearing contractors subcontracted these operations, so that logging activities would not conflict with clearing operations.

The researchers determined from project visits and telephone conversations that at several projects more vegetation could have been salvaged if there had been more time to complete the clearing operation. Often, the contract award was impeded by bids being contested or other delays. When the contract was awarded, the time for completing the clearing operation was sufficient only if logging or other forms of salvage were not included.

In some areas of the United States, many valuable trees are located on sites being cleared for impoundments. If more time were provided for tree removal, it would be possible to: (1) use the most efficient, economical, and effective method to dispose of the vegetation; (2) locate more markets for the vegetation; (3) provide these markets with the vegetation over a longer period of time to meet the demands of the markets when they occur; or (4) find more uses for the vegetation.

In some cases, this could reverse the clearing contract procedure. Instead of the government paying to have sites cleared of vegetation, contractors would pay the government for the clearing contract, because the sale of the wood would more than compensate for their expenses.

4 FACTORS TO CONSIDER FOR SELECTION OF DISPOSAL METHODS

Many factors must be considered when determining the best method for disposing of vegetation cleared at a particular site. Each site should be considered separately, since the conditions of each will vary. If possible, the cut vegetation should be used beneficially and not destroyed.

The following list of factors was prepared for evaluating methods for disposing of cleared vegetation. No system or method for weighting the factors was established, since the importance of the individual factors changed at each site.

Vegetation

1. Characteristics
   a. Type and quality of vegetation
   b. Quantity of vegetation (sites and project)
   c. Size of vegetation
2. Location
   a. Accessibility to clearing/disposal site
   b. End use of the cutting/disposal site
3. Clearing (Felling Method)
   a. State of felled vegetation
   b. Need for additional processing for disposal.

General Physical Environment

1. Area topography and local relief (terrain)
2. Type and depth of soil
3. Type and depth of bedrock
4. Depth of water table
5. Climate and extreme weather conditions
6. Amount of annual surface runoff

7. Low flow period of streams in the watershed.

Public Opinion

1. Proximity of clearing/disposal sites to populated areas, highways, etc.

2. Accessibility to clearing/disposal site

3. Public response to disposal operations that have occurred in the area

   a. Open burning of leaves, trash, etc., by residents

   b. Public/private landfill operations

   c. Objections to disposal methods.

Safety

1. Workers

2. Populace.

Environmental Considerations

1. Potential problems with:

   a. Land and land-use compatibility

   b. Water, surface, and groundwater quality

   c. Air quality

   d. Noise, shock, and vibration.

Legal Considerations

1. Potential conflicts with:

   a. Federal laws and regulating agencies (see Appendix C)

   b. State laws and regulating agencies (see Appendix D)

   c. Local laws and ordinances and regulating agencies

2. Permits issued by regulating agencies

3. Operating requirements

a. Equipment and operating procedures

b. Climatic and forest conditions.

Economic Considerations

1. Labor costs

2. Processing costs

3. Transportation costs

4. Proximity to disposal sites

5. Market demands

6. Proximity to market

7. Comparison of market value of material to total costs for processing/transporting to market.

When choosing a disposal method, cost is an important factor.

The disposal site should be located at the clearing site or as close to it as possible to minimize transportation costs.

The vegetation should not be processed unless it is absolutely necessary for the disposal operation. Frequently, the clearing operation will provide all the processing necessary for the disposal operation. If processing is used to make the vegetation marketable, the costs of the processing should be included in the market price.

It may be more economically feasible to use a more expensive clearing method that prepares the vegetation more adequately for disposal and to eliminate or reduce the later processing.

In most situations, one of the most economical methods of disposal is to pile (windrow) and burn the vegetation in an unconfined manner.

The following formula and production table (Table 2) were developed by Rome Plow Company for determining the piling time per acre (in minutes) for a crawler tractor equipped with a rake.[6]

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[6] *Effective Methods of Land Clearing* (Caterpillar Tractor Company), pp 29-30.

Table 2

Production Table for Piling*

Caterpillar[1] Tractor	Base[2] Minutes (B)	Dia. Range[3] 1-2 ft (.30-.61 m) M_1	Dia. Range 2-3 ft (.61-.91 m) M_2	Dia. Range 3-4 ft (.91-.21 m) M_3	Dia. Range 4-6 ft (1.21-1.83 m) M_4	For Dia. Over[4] 6 ft (1.83 m) per foot (.30 m) (F)
D9G	45	0.1	0.2	1.4	2.4	0.4
D8H	50	0.2	0.6	2.0	4.0	1.0
D7E	60	0.4	0.8	3.0	6.0	---
D6C	75	0.6	1.2	5.0	---	---

[1]Based on current-model tractors working on reasonable level terrain (below 10 percent grade) with good footing and no stones in an average mixture of soft and hard woods. Tractor should be in proper operating condition and have a sharp shear blade. (Caterpillar is registered trademark of Caterpillar Tractor Co.)

[2]The base figures represent the number of minutes required for each tractor to cover an acre (.41 hectare) of light material where no trees require splitting or other individual treatment.

[3]M_1 represents the minutes required to cut trees from 1 to 2 ft (.30 to .61 m) in diameter at ground level. M_2 is the factor for trees in the 2 to 3 ft (.61 to .91 m) diameter range. M_3 is the factor for trees in the 3 to 4 ft (.91 to 1.21 m) diameter range. M_4 is the factor for trees in the 4 to 6 ft (1.21-1.83 m) diameter range.

[4]The figures in this column represent the number of minutes required per foot (.30 m) of tree diameter for each tractor to cut trees of more than 6 ft (1.83 m) in diameter.

*If the stumps have been grubbed out, add 25 percent to the total time calculated to pile the vegetation. If three or more tractors are used in combination to pile the vegetation, subtract 25 to 50 percent from the total time per tractor.

$$T = B + M_1N_1 + M_2N_2 + M_3N_3 + M_4N_4 + DF$$

where T = Time per acre in minutes

B = Base time for each tractor per acre

M = Minutes per tree in each diameter range

N = Number of trees per acre in each diameter range obtained from field cruise

D = Sum of diameter in feet of all trees per acre over 6 ft (1.83 m) in diameter at ground level obtained from field cruise

F = Minutes per foot of diameter for trees over 6 ft (1.83 m) in diameter.

When the piles of vegetation are set on fire, a crawler tractor with a rake attachment can be used to repile the burning material. The time required for this operation varies between 30 min and 1 hr of tractor time for each acre.

After the total time that each piece of equipment will be needed for the disposal operation has been determined, the average operating cost can be multiplied by the total number of hours to determine the cost for equipment at the site. Most dealers can provide the average operating cost, which includes fuel, normal maintenance, and depreciation. Wages will vary and must be included.

Some heavy equipment dealers can provide the information necessary to determine the capital amortization and operating costs per hour for each piece of heavy equipment they sell. These costs should include fixed and variable overhead, fixed and variable machine costs, depreciation, interest, insurance, taxes, fuel, lubricants, repairs, wages, and expense of attachments involved.

Manufacturers do not guarantee the accuracy of their production tables because of the number of variables that can increase or decrease production.

Most states that prohibit unconfined burning approve the use of pit incinerators; others require operation permits and have operating requirements.

The prices of air sources (blowers) vary but usually depend on the size of the nozzle section, power source, and whether the model is portable. Other options influence the price but to a lesser degree. A detailed discussion of representative blower prices, models, options, delivery costs, etc., is provided in CERL Interim Report E-77/ADA024751, *Disposal of Cleaning Debris*, published in April 1976.

At some sites, burying unprocessed vegetation is the best means for disposing of cleared vegetation. The necessary equipment for excavating and burial operations may already be in the project area.

The equipment could be used at the disposal operation when not being used at the dam site. Clearing operations are often conducted when weather conditions are unsuitable for work at the dam site. During this time, the excavation can be done, the vegetative debris placed in the pit, and cover material moved over the debris.

Salvage operations must be done prior to the disposal operation. Additional processing should be avoided to minimize disposal costs.

Production formulas for different types of machinery adequate for excavation and burial operations are available from most equipment dealers.

Cleared vegetation should be used because it is a resource. If the contractor can sell some or all of the vegetation, the income can reduce the cost of the clearing operation to the government.

The contractor must consider several marketing factors. Each location must be considered individually to determine the marketability of cleared vegetation. The cost of the processing, if necessary to make the vegetation marketable, must be included in the selling price. The distance to the market and handling and transportation costs must be considered if the material will be delivered. The contractor must also consider the completion date of the clearing operation (time factor). Salvage operations may increase the time needed to complete the clearing and disposal operations.

5 CLEARING VERSUS CLEANING

Discussions with COE personnel (lockmasters, project managers, project engineers, area engineers, and resource managers) produced arguments for and against expanding the clearing operations while the dam is being constructed. Researchers were unable to establish a universal policy that would be applicable to all impoundments; they determined that each project would have to be evaluated separately. Some major factors to be considered are:

1. The Dam. Is the dam designed to pass (flush) the debris downstream, or will the dam trap the debris and necessitate frequent cleaning operations? What are the functions of the dam? Will the accumulation of the debris impede the functions of the dam on the waterway?

2. Debris. How much vegetative debris can be expected to be washed down from the watershed? How much vegetation will be permanently inundated by the impoundment and will subsequently rot, fall into the water, and become debris to be removed in cleaning operations?

3. Disposal. Will there be many areas around the impoundment where the floating debris can be collected, removed, and disposed of economically? Would it be easier and less expensive to clear and dispose of the vegetation prior to filling the impoundment?

4. Other Considerations. At most sites, it is easier to conduct clearing than cleaning operations. There are more possible sites for the disposal of clearing debris than for cleaning debris after the impoundment has been filled. At some sites, clear cutting can produce conditions that will promote large-scale erosion problems.

If the area to be permanently inundated by the impoundment is cleared of vegetation, the costs of the clearing operation may produce an unfavorable cost/benefit ratio for the project; however, if the area is not cleared prior to filling the impoundment, the costs for removing the debris at a later time are passed on to the dam's operation and maintenance costs. The costs of clearing and cleaning operations are increasing constantly. Would it be cheaper to clear the area of vegetation during construction or clean out the floating debris later?

At most sites, some or most of the cleared vegetation can be sold or used in some manner. The quality and quantity of cleaning debris is normally such that it cannot be sold or used.

6 CONTRACT SPECIFICATIONS

The way the specifications for the clearing contract are written greatly affects the operation's outcome. Poorly written specifications can cause confusion and misunderstandings.

All clearing specifications and supplementary information must be written so that the contractor will understand (1) what the job requirements are, (2) what the job limitations are, and (3) what is expected by the COE. The COE can expect to pay more per area for land-clearing operations if the contract specifications are not written clearly and concisely. If a contractor does not completely understand the job, he will understandably bid higher to protect himself from the possibility of losing money.

Some points that should be remembered when writing clearing contract specifications are:

1. State terms clearly and concisely. Define terms that may lead to misunderstandings, i.e., "brush," "trees," "scattered trees," "complete clearing," "modified clearing," and the like.

2. Specify the job requirements exactly. Use dimensions, examples, diagrams, comparisons, etc., to illustrate what is wanted.

3. Clearly define the end use of the land and the expected condition of the land when the clearing activities have been completed.

4. After considering all the factors that can affect the clearing activities and the total time requirement, specify a realistic completion date (try to include enough time so that logging and other salvage operations can be performed).

5. Avoid rigid specifications that may force the clearing contractor to use less efficient and effective clearing and disposal methods.

6. Specifications should be written for each operation that is required (i.e., clearing, removal, and disposal) with as few "as directed" or "with the approval of the contracting officer" statements as possible.

7. The job requirements should not call for more work than is absolutely necessary.

8. If clear cutting and grubbing are necessary, be sure the work to be done is really land clearing and not earthmoving. A major earthmoving project should be accomplished under a separate contract.

9. When determining the disposal methods or requirements, be aware of the number of factors that can affect the operation. Always stress the fact that cleared vegetation should be used if possible.

10. Logging or other salvage activities should not be done concurrently with clearing operations. The logging and salvage operations should be controlled by the clearing contractor, not COE personnel.

11. Most clearing contracts stipulate that the clearing contractor will be responsible for conducting clearing and disposal operations in a method that complies with federal, state, and local environmental laws. The contract should refer to the applicable laws and the responsibility of the clearing contractor to obtain permits and meet the requirements of the regulating agencies.

12. It would be helpful to the contractor if the following items were supplied to him:

a. Aerial photographs of the areas to be cleared of vegetation

b. A general topographic map of the entire area

c. Climatic data, including monthly means and extremes of temperature and precipitation

d. A soils map for the project area which includes soil types and the depth to bedrock

e. A map which shows the depths of the water table in the project area

f. A general road map of the area which shows access routes to and throughout the area

g. The results of vegetative surveys and the general physical conditions at the sites.

Figure 31 illustrates a problem that can occur during clearing activities. The contractor may cut vegetation and pile it in the floodplain for later disposal. An unexpectedly large amount of precipitation in the headwaters of the river may produce flood conditions downstream in the project area and float the debris downstream into the dam site.

Cut vegetation, wood chips, etc., should be placed above the high-water level of adjacent streams and rivers if they must be stored for a long time.

Figure 32 shows that drift is another problem that may arise if it is not covered clearly and concisely in the clearing contract. Drift

Figure 31. High water may move piled vegetation.

Figure 32. Drift.

material should be defined and covered by the clearing contract if no other provisions have been made to remove it. In some areas of the United States, a large amount of drift is washed down onto the floodplains of rivers and streams from the headwaters and surrounding uplands. Drift that has already been deposited in the project area should be disposed of before filling the impoundment.

In some states, activities similar to those shown in Figure 33 are illegal. The movement of heavy equipment or vehicles across or up or down stream beds is prohibited, since such activities disturb the stream bed and spawning areas of fish. The movement of equipment and vehicles up and down the banks of streams and rivers may also promote erosion. If no alternative can be found, most regulating agencies will allow such activities, but will usually stipulate special operating procedures.

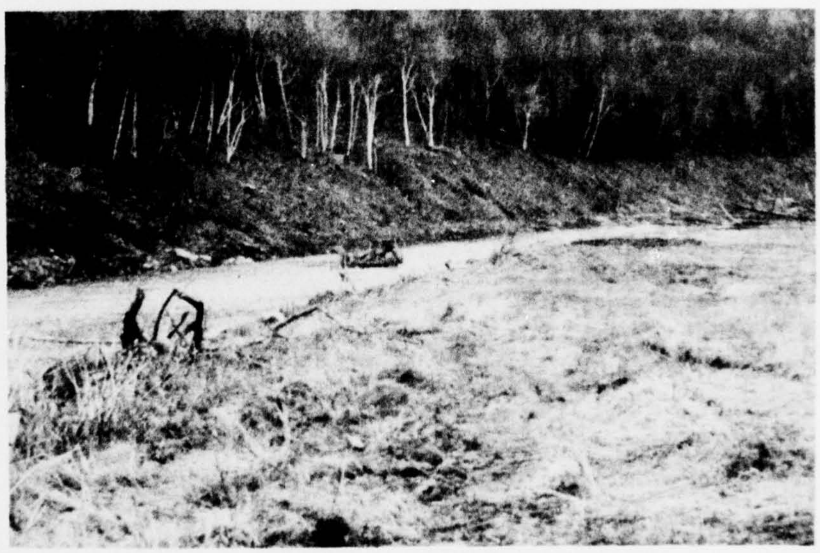

Figure 33. Moving equipment across stream bed.

7 CONCLUSIONS

Chapter 4 provides planning, construction, and operations personnel with the factors needed to evaluate methods of disposing of clearing debris at water impoundments. This research effort led to the following conclusions:

1. The COE will clear less forested land for impoundments in 1980 than in 1970, but will produce more vegetative debris, because these areas will have denser stands of vegetation.

2. Selection of a disposal method for cleared vegetation must be based on many complex and interacting factors, including new environmental laws and regulations.

3. No universal method can be used at every site to dispose of cleared vegetation; each site must be evaluated individually.

4. Cleared vegetation is a resource and should be used or sold if possible. The type, size, quality, and quantity of the vegetation are important factors that must be considered when trying to determine its use or marketability. A survey of the project area's vegetation should be conducted to obtain this information before beginning clearing and disposal operations.

5. Clear cutting (complete cutting) is the major type of clearing conducted at COE impoundments. Large-scale mechanical clearing operations could be conducted on the flat floodplains, but in most cases these areas have been farmed previously and are relatively devoid of natural vegetation. The adjacent slopes may be steep, gullied, and contain boulders and rock outcrops which do not facilitate mechanical clearing activities. Manual clearing with lightweight power chain saws allows the operators to traverse rugged areas and still maintain a high production rate. Removal of the vegetation may be a problem if it cannot be disposed of at or near the cutting site.

6. The costs of manual clearing operations are competitive with mechanical clearing operations at most projects. The size of most projects and the amount of most clearing contracts are not large enough to support large-scale mechanical clearing activities.

7. At some impoundments, it might be advantageous to expand clearing operations to include additional areas that will be permanently inundated by the body of water. Such action could reduce the amount of floating debris that will have to be removed from the water and disposed of after the impoundment is filled. Driftwood present in the project area before the impoundment is filled should be included in the clearing contract.

8. The allowed time for completing the clearing and disposal operations at impoundment projects should enable the contractor to properly dispose of all wood that can be sold or used beneficially. Wood having a high value per unit volume which will support the additional costs of processing, handling, and transporting should be removed from the site and not destroyed.

8 FUTURE RESEARCH

During Phase Four, researchers will evaluate state environmental laws that may apply to debris disposal operations conducted at COE impoundments. The final report prepared during this phase will summarize all previous research and emphasize the management concepts and implications of environmental laws that affect viable alternatives for debris disposal.

APPENDIX A: EXPLANATION OF DATA CALCULATIONS

The following data were obtained from Appendices B and C of the October 1973 U.S. Environmental Protection Agency publication *Solid Waste Management in Land Clearing and Logging Operations*. The appropriate appendix source and table number is in brackets following the figures.

In 1970, the Corps of Engineers (COE), Soil Conservation Service (SCS), and Department of the Interior had an estimated 198,440 acres (80 368 hectares) [B-6] involved in water impoundment projects. The COE accounted for approximately 77 percent of the total acreage, or 154,120 acres (61 600 hectares) [B-6].

During 1970, the three federal agencies cleared an estimated 54,595 acres (22 111 hectares) [C-1] of forested land. These clearing operations produced an estimated 2.8 million tons (2.6 million metric tons) [C-3] of vegetative debris.

For this report, researchers assumed the COE cleared 77 percent of the total acreage cleared by the three agencies in 1970--42,000 acres (16 800 hectares). Seventy-seven percent is the same proportion of the total amount of acreage the COE had involved in water impoundment projects. Researchers also assumed the COE clearing operations accounted for 77 percent of the total amount of vegetative debris generated by the three agencies' clearing operations in 1970--2.2 million tons (2 million metric tons).

Projections indicate that the COE and SCS will have an estimated 159,755 acres (64 700 hectares) [B-7] involved in water impoundment projects in 1980. The COE will account for 72 percent of the total acreage or 116,000 acres (46 400 hectares) [B-7].

In 1980, the COE and SCS will clear an estimated 49,487 acres (20 042 hectares) [C-2] of forested land. The two agencies' clearing operations are expected to generate approximately 3.3 million tons (3 million metric tons) [C-4] of vegetative debris.

Researchers assumed the COE would clear 72 percent of the projected total acreage to be cleared by the two agencies in 1980--36,000 acres (14 400 hectares). This is the same proportion of the total amount of acreage the COE will have in projected water impoundment projects in 1980. Researchers also assumed the COE clearing operations would generate 72 percent of projected total vegetative debris--2.4 million tons (2.2 million metric tons).

APPENDIX B: ER 415-2-1--CONSTRUCTION, POLICIES and PRACTICES--CLEARING

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DEPARTMENT OF THE ARMY
Office of the Chief of Engineers
Washington, DC 20315

ER 415-2-1

ENGCW-OC

Regulation
No. 415-2-1

3 June 1969

CONSTRUCTION

Policies and Practices--Clearing

1. Purpose and Scope. This regulation prescribes general policies for clearing civil works reservoir areas by divisions and districts.

2. Applicability. This regulation applies to all divisions and districts engaged in Civil Works activities.

3. General Objective. In planning the clearing of reservoir areas, the general objectives will be: to clear only to the extent required in order to effect an overall reduction in construction costs, to clear areas that would otherwise create hazards to the primary project purposes, but not to clear to an extent which will create a maintenance problem from regrowth. This planning will take cognizance of the fact that floatable debris from sources within the reservoir area does not normally constitute an appreciably greater problem than exists from debris originating outside the reservoir area. Planning will also take into account the following:

a. Minimum public health hazards.

b. Eliminating operational hazards.

c. Minimum interference with navigation.

d. Maximum practicable benefits to fish and wildlife within scope of authorization.

e. Effecting maximum possible salvage of timber.

f. Achieving a good general appearance particularly in those areas most used by the public.

g. Eliminating pollution.

h. The environment and aesthetics of the area.

4. Clearing Limits. These are divided into two general classifications: vertical and horizontal. The vertical limits are further divided into upper and lower limits. The vertical limits are the controlling limits. Horizontal limits, when applied, are normally within the vertical limits. Guidelines for applying vertical and horizontal limits are as follows:

This regulation rescinds ER 415-2-1, 18 July 1966

a. Vertical Limits.

(1) The upper limit of clearing will generally be 0' to 3' above the appropriate pool or sufficient horizontal distance, whichever is less, to insure that all possible timber subject to "tree kill" will be removed. These will generally be as follows:

(a) Flood Control Reservoirs--0' to 3' above the maximum conservation, winter or permanent pool.

(b) Multiple Purpose Reservoirs--0' to 3' above the maximum power pool. Any project having a "project purpose" (i.e., downstream power, water supply, etc.) which requires a drawdown of the pool will be treated as a multiple purpose reservoir.

(c) Navigation Reservoirs--0' to 3' above the normal operating pool.

(2) The lower limit of clearing will generally be as follows:

(a) Flood Control Reservoirs--5' below the minimum conservation, winter or permanent pool.

(b) Multiple Purpose Reservoirs--5' below the 10-year frequency drawdown.

(c) Navigation Reservoirs--Complete clearing within the navigation channel. Such clearing as necessary of vegetation not adaptable to flooding from the navigation pool within the normal operating pool to prevent snags and floating debris which will create hazards to navigation. All other clearing will be accomplished 5' below the normal operating pool.

(d) In those cases where water supply will be an authorized project purpose, the lower limit of clearing will be the bottom of the reservoir if this procedure is cheaper than effecting the counteracting water treatment required. The costs of the additional clearing required constitutes a specific cost for water supply. Note that the primary objection of non-clearing with respect to water supply is dissipated over a period generally of less than 10 years. Special consideration should also be given to removing all possible sources of pollution.

(3) No clearing in reservoirs where winter or other pools are not authorized.

(4) In isolated areas and tributaries where hazards to public health, appearance and recreational use are not evident, no clearing will be accomplished.

b. Horizontal Limits. The horizontal limits given below with regard to main dams, public use areas, highway crossings and existing or proposed major populated areas are generally considered to be the minimum. The horizontal limits are generally as follows:

(1) The horizontal extent of clearing will be the total of areas for which clearing is required for specific purposes only, to include mosquito control, appearance factors, debris problems, operational standards, and other items referred to in the preceding paragraph. Some of the items are discussed in the following subparagraphs.

(2) Generally complete clearing within the pool will be done within one mile of any part of the main dam structure. However, in the non-pool portions of the dam site area, clearing limits will be established very carefully to avoid despoiling what may be one of the most important natural resource areas of the project.

(3) Clearing within the pool will be done within one mile of each primary public use area. This limit may be expanded if necessary to permit access from public use areas to major reservoir pool areas.

(4) Clearing will be done within one-half mile of each highway crossing of the reservoir.

(5) Clearing will be done within one mile of each existing or proposed major populated area. An existing major populated area is defined as any area of 100 acres or more having a population density in excess of one-half person per acre. A proposed major populated area is one in which it is anticipated that the population will equal or exceed the limits of an existing major populated area within three years after the reservoir is placed in operation.

(6) Any areas in which the cost of clearing performed for mosquito control alone is less than the additional cost of required mosquito control measures if clearing is not done.

(7) Precautions will be taken to protect the area adjacent to the upper limit of clearing, especially along those sections of shoreline adjacent to the dam site, recreational use areas, highway crossings, near populated areas, and any significantly important resource, natural or man made, such as a historical site or outstanding geological formation. These precautions will include protection of shrub species within 1 to 3 feet horizontally of the clearing line, suitable survey methods for defining or marking the upper limits of clearing with least amount of damage to vegetation, control of felling of large trees onto trees and tree areas outside of the clearing line, and maneuvering of equipment by the contractor on non-road areas outside of the clearing line.

5. Timber Salvage. Every effort will be made to coordinate clearing operations to the extent that maximum benefit will be derived from the salvage of usable timber. This objective will require additional time which must be allowed for in project planning.

6. Clean Up. The extent of clearing and clean up generally to be followed in all reservoir areas is contained in the Guide Specifications, Civil Works Construction, CE 1301, on Clearing.

FOR THE CHIEF OF ENGINEERS:

Philip T Boerger

PHILIP T. BOERGER
Colonel, Corps of Engineers
Executive

APPENDIX C: FEDERAL ENVIRONMENTAL CONTROL AGENCIES

DEPT. OF AGRICULTURE

Agricultural Research Service
14th & Independence Ave., S.W.
Washington, DC 20250

Cooperative State Research Service
14th & Independence Ave., S.W. (Admin. Bldg.)
Washington, DC 20250

Extension Service
5503 S. Agriculture Bldg.
14th & Independence Ave., S.W.
Washington, DC 20250

Forest Service
South Agriculture Bldg.
12 & Independence Ave., S.W.
Washington, DC 20250

DEPT. OF COMMERCE

Economic Development Administration
Main Commerce Bldg.
14th & Constitution Ave., N.W.
Washington, DC 20230

Maritime Administration
14th & E Sts., N.W.
Washington, DC 20235

Natinal Bureau of Standards
Institute of Materials Research
Gaithersburg, MD 20850

National Industrial Pollution Control Council
Room 4845, 14th & Constitution Ave., N.W.
Washington, DC 20230

National Oceanic and Atmospheric Administration
6010 Executive Blvd.
Washington Science Center, Room 221
Rockville, MD 20852

National Marine Fisheries Services
3300 Whitehaven St., N.W.
Washington, DC 20235

National Environmental Satellite Service
Federal Office Bldg. #4
Suitland, MD 20233

Office of Sea Grants
National Oceanographic and Atmospheric Administration
Rockville, MD 20852

National Ocean Survey
6001 Executive Blvd., Bldg. #1
Washington Science Center
Rockville, MD 20852

Environmental Research Laboratories
Boulder, CO 80302

Environmental Data Service
3300 Whitehaven St., N.W.
Washington, DC 20235

DEPT. OF DEFENSE

Department of Defense
OASD (H&E) EQ
3D171, The Pentagon
Washington, DC 20301

Department of the Air Force
5E425, The Pentagon (AF/PREV)
Washington, DC 20330

Department of the Army
Headquarters DA
DALO-INE
Washington, DC 20310

Corps of Engineers
Department of the Army, Office of Chief of Engineers
Washington, DC 20314

Department of the Navy
Environmental Protection Division
Office of Chief of Naval Operations
4B468, The Pentagon
Washington, DC 20350

DEPT. OF HOUSING & URBAN DEVELOPMENT

Community Planning and Management
451 7th St., S.W.
Washington, DC 20410

DEPT. OF THE INTERIOR

Bureau of Land Management
18th & C Sts., N.W.
Washington, DC 20240

Bureau of Outdoor Recreation
18th & C Sts., N.W.
Washington, DC 20240

Fish and Wildlife Service
18th & C Sts., N.W.
Washington, DC 20240

Geological Survey
General Services Bldg.
18th & F Sts., N.W.
Washington, DC 20240

National Park Service
18th & C Sts., N.W.
Washington, DC 20240

Office of Saline Water
1900 Constitution Ave., N.W.
Washington, DC 20240

Office of Water Resources Research
18th & C Sts., N.W.
Washington, DC 20240

DEPT. OF JUSTICE

Land & Natural Resources
10th & Constitution Ave., N.W.
Washington, DC 20530

DEPT. OF LABOR

Manpower Administration
14th St. & Constitution Ave., N.W.
Washington, DC 20210

DEPT. OF STATE

Office of Environmental Affairs
2201 C St., N.W.
Washington, DC 20520

DEPT. OF TRANSPORTATION

Coast Guard
400 7th St., S.W.
Washington, DC 20590

Office of Marine Environment and Urban System
U.S. Coast Guard
400 7th St., S.W.
Washington, DC 20590

Federal Aviation Administration
800 Independence Ave., S.W.
Washington, DC 20591

Federal Highway Administration
400 7th St., S.W.
Washington, DC 20590

Federal Railroad Administration
400 7th St., S.W.
Washington, DC 20590

Environment Safety and Consumer Affairs
400 7th St., S.W.
Washington, DC 20590

Office of Environmental Affairs
400 7th St., S.W.
Washington, DC 20590

Systems Development and Technology
400 7th St., S.W.
Washington, DC 20590

Urban Mass Transportation
400 7th St., S.W.
Washington, DC 20590

ENVIRONMENTAL PROTECTION AGENCY

Waterside Mall Building
Room W 1200, West Tower
4th and M Sts., S.W.
Washington, DC 20460

OTHER OFFICES AND AGENCIES

Council on Environmental Quality
722 Jackson Place, N.E.
Washington, DC 20506

General Accounting Office
441 G St., N.W.
Washington, DC 20548

Office of Management and Budget
Executive Office Bldg.
Washington, DC 20503

Atomic Energy Commission
Washington, DC 20545 (Mail Address)
Germantown, MD (Main Office)
7920 Norfolk Ave., Bethesda, MD; and
1717 H St. N.W., Washington, DC

Federal Maritime Commission
1405 Eye St., N.W.
Washington, DC 20573

Federal Power Commission
825 N. Capitol St., N.E.
Washington, DC 20426

General Services Admin.
18th & F Sts., N.W.
Washington, DC 20405

National Academies of Sciences and Engineering
2101 Constitution Ave., N.W.
Washington, DC 20418

National Aeronautics and Space Admin.
400 Maryland Ave., S.W.
Washington, DC 20546

National Science Foundation
1800 G St., N.W.
Washington, DC 20550

Smithsonian Institution
1000 Jefferson Dr., S.W.
Washington, DC 20560

Tennessee Valley Authority
New Sprankle Bldg.
Knoxville, TN 37902

Tennessee Valley Authority
Woodward Bldg., 15th & H Sts, N.W.
Washington, DC 20444

Tennessee Valley Authority
Div. of Environmental Planning
Chattanooga, TN 37401

United States Information Agency
1776 Pennsylvania Ave., N.W.
Washington, DC 20547

INTERSTATE ENVIRONMENTAL AGENCIES

Delaware River Basin Commission
Box 360
Trenton, NJ 08603
Cooperating States: Delaware, New Jersey, New York, Pennsylvania, United States

Interstate Commission on the Potomac River Basin
Suite 814, 4350 East-West Hwy.
Bethesda, MD 20014
Cooperating States: District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia

Interstate Sanitation Commission
10 Columbus Circle, Room 1620
New York, NY 10019
Cooperating States: Connecticut, New Jersey, New York

New England Interstate Water Pollution Control Commission
607 Boylston St.
Boston, Mass. 02116
Cooperating States: Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont

Ohio River Valley Water Sanitation Commission
414 Walnut St.
Cincinnati, Ohio 45202
Cooperating States: Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, West Virginia

Great Lakes Commission
5104 1st Bldg.
2200 N. Campus Blvd.
Ann Arbor, Mich. 48105
Cooperating States: New York, Pennsylvania, Ohio, Michigan, Wisconsin, Minnesota, Illinois, Indiana (also represents Canada unofficially)

Susquehanna River Basin Commission
5012 Lenker St.
Mechanicsburg, PA 17055
Cooperating States: New York, Pennsylvania, Maryland, Federal Government

APPENDIX D: STATE ENVIRONMENTAL CONTROL AGENCIES

Alabama

Coordinating Agency:

Environmental Health Administration
State Office Bldg.
Montgomery 36104

Air:

Air Pollution Control Commission
645 South McDonough St.
Montgomery 36104

Water:

Chief Administrative Officer
Water Improvement Commission
Director
Division of Public Water Supplies

Solid Wastes:

Solid Waste and Vector Control
State Health Department
State Office Building
Montgomery 36104

Alaska

Coordinating Agency:
Commissioner
St. Ann's Center
Pouch O
Juneau 99801

Air and Water:

Division of Water and Air Quality Control

Land Use and Urban Development:

Division of Land Use and Urban Development

Alaska (cont)

Marine and Coastal Zone Management:

Division of Marine and Coastal Zone Management

Permafrost and Soils Engineering

Arizona

Coordinating Agency:

Asst. Commissioner for Environment
Health Bldg.
1740 West Adams St.
Phoenix 85017

Air:

Director of Air Pollution Control

Water:

Director
Division of Water Quality Control

Solid Wastes:

Director
Division of Sanitation

Arkansas

Coordinating Agency:

Arkansas Pollution Control Commission
8001 National Dr.
Little Rock 72209

Air:

Chief of Air Pollution Control

Water:

Chief of Water Pollution Control

Solid Wastes:

Chief

Land Use Control:

Chief, Environmental Preservation

California

Air:

Air Resources Board
1025 P St.
Sacramento 95814

Water:

State Water Resources Control Board
1416 Ninth St.
Sacramento 95814

Noise:

Secretary for Resources

Solid Wastes:

Solid Wastes Management Board

Land Use Control:

Dept. of Conservation

Coastal Resources:

Statewide Coastal Zone Conservation Commission
1540 Market St., 2nd Floor
San Francisco 94102

Colorado

Coordinating Agency:

Colorado Dept. of Health
4210 E. 11th Ave.
Denver 80220

Air:

Air Pollution Control

Water:

Water Pollution Control

Solid Wastes:

Chief of Engineering
Engineering and Sanitation Division

Connecticut

Coordinating Agency:

Dept. of Environmental Protection
State Office Bldg.
165 Capitol Ave.
Hartford 06115
(address central for all agencies)

Air:

Air Compliance Unit
Room 188

Water:

Water Compliance
Room 129

Solid Wastes:

Solid Waste Management
Room 123

Delaware

Coordinating Agency:

Dept. of Natural Resources and Environmental Control
Tatnall Bldg.
Capitol Complex
Dover 19901
(address central for all agencies)

Air:

Air Resources Division

Water:

Water Resources Section

Noise:

Under Air

Solid Wastes:

Solid Waste Section

Land Use Control:

Under Air

Delaware (cont)

Coastal Resources:

Division of Wetlands

Florida

Coordinating Agency:

Dept. of Pollution Control
315 S. Calhoun St.
Tallahassee 32301

Georgia

Coordinating Agency:

Division of Environmental Protection
Dept. of Natural Resources
47 Trinity Ave., S.W.
Atlanta 30334
(address central for all agencies
unless otherwise noted)

Air:

Air Quality Control Section

Water:

Water Quality Control Section
Water Supply Section

Noise:

Under Dept. of Human Resources

Solid Wastes:

Solid Waste Management Section

Land Use Control:

Land Reclamation Section
Box 4825
Macon 31208

Hawaii

Coordinating Agency:

Director of Health
Division of Environmental Health
P.O. Box 3378
Honolulu 96801

Air and Water:

Air Sanitation Branch

Solid Wastes:

Executive Officer

Idaho

Coordinating Agency:

Dept. of Environmental and Community Services
and Director of Environmental Services
State House
Boise 83720

Air:

Director
Air and Water Programs

Solid Wastes:

Chief
Solid Waste Program

Illinois

Coordinating Agency:

Illinois Environmental Protection Agency
2200 Churchill Road
Springfield 62702
(address central for all agencies)

Air:

Division Manager
Air Pollution Control

Water:

Division Manager
Water Pollution Control

Illinois (cont)

Noise:

Division Manager
Noise Pollution

Solid Wastes:

Division Manager
Land Pollution

Indiana

Coordinating Agency:

Indiana State Board of Health
1330 W. Michigan St.
Indianapolis 46206
(address central for all agencies)

Air:

Air Pollution Control Board

Water:

Technical Secretary
Stream Pollution Control Board
Director
Water Pollution Control Division

Solid Wastes:

Director
Sanitary Engineering Division

Iowa

Coordinating Agency:

Dept. of Environmental Quality
Iowa State Dept. of Health
3920 Delaware Ave., P.O. Box 3326
Des Moines 50316

Air:

Director
Air Quality Management

Iowa (cont)

Water:

Director
Water Quality Management
Director
Water Supply

Kansas

Coordinating Agency:

Division of Environmental Health
Kansas State Dept. of Health
535 Kansas, 4th Floor
Topeka 66612
(address central for all agencies)

Air:

Air Quality & Occupational Health Section

Water:

Water Pollution Control

Noise:

Occupational Health Engineer

Solid Wastes:

General Community Sanitation

Kentucky

Coordinating Agency:

Dept. for Natural Resources and Environmental Protection
Capitol Plaza Tower, 6th Floor
Frankfort 40601
(address central for all agencies unless otherwise noted)

Air:

Director
Air Pollution Control Commission
275 E. Main
Frankfort 40601

Kentucky (cont)

Water:

Director
Division of Water

Noise:

Division of Special Programs
5th Floor

Solid Wastes:

Director
Health Bldg.
Frankfort 40601

Louisiana

Coordinating Agency:

Bureau of Environmental Health
Division of Engineering, Solid Waste, Sewage
Derived Water Pollution
Louisiana State Dept. of Health
P.O. Box 60630
New Orleans 70160
(address central for all agencies)

Air:

Head
Division of Air Control and Occupational Health

Chief
Air Control Section
Bureau of Environmental Health

Maine

Coordinating Agency:

Department of Environmental Protection
State House
Augusta 04330
(address central for all agencies unless otherwise noted)

Air:

Bureau of Air Quality Control

Maine (cont)

Water:

Bureau of Water Quality Control

Solid Wastes:

Division of Solid Waste Management

Land Use Control:

Bureau of Land Quality Control

Maryland

Coordinating Agency:

Maryland Dept. of Natural Resources
Tawes State Office Bldg.
Annapolis 21401
(address central for all agencies)

Air:

Health & Mental Hygiene

Water:

Water Resource Administration

Solid Wastes:

Maryland Environmental Service
Sewage & Solid Waste Disposal

Land Use Control:

Program Planning & Evaluation

Massachusetts

Coordinating Agency:

Bureau of Air Quality Control
Division of Environmental Health
Dept. of Public Health
600 Washington St.
Boston 02111

Air:

Above

Massachusetts (cont)

Water:

Division of Water Pollution Control
Dept. of Natural Resources
Leverett Saltonstall Bldg.
Government Center
100 Cambridge St.
Boston 02202

Michigan

Coordinating Agency:

Department of Natural Resources
3500 N. Logan
Lansing 48914
(address central for all agencies unless otherwise noted)

Air:

Division of Air Pollution Control

Water:

Water Resources Commission
Stevens T. Mason Bldg., 8th Floor
Lansing 48926

Noise:

Bureau of Industrial Health

Solid Wastes:

Division of Solid Waste Management

Minnesota

Coordinating Agency:

Minnesota Pollution Control Agency
717 Delaware St., S.E.
Minneapolis 55440
(address central for all agencies unless otherwise noted)

Air:

Division of Air Quality

Minnesota (cont)

Water:

Division of Water Quality

Noise:

Under Air Quality

Solid Wastes:

Division of Solid Wastes

Mississippi

Coordinating Agency:

Mississippi Air and Water Pollution Control Commission
P.O. Box 827
Jackson 39205
(address central for all agencies unless otherwise noted)

Air:

Air Division

Water:

Water Division

Solid Wastes:

Sanitary Engineering Division
State Board of Health
P.O. Box 1700
Jackson 39205

Missouri

Coordinating Agency:

Missouri Clean Water Commission
1014 Madison St.
P.O. Box 154
Jefferson City 65101

Air:

Missouri Air Conservation Commission
P.O. Box 1062
Jefferson City 65101

Missouri (cont)

Solid Wastes:

Section of Environmental Health
Broadway State Office Bldg.
Jefferson City 65101

Montana

Coordinating Agency:

Environmental Sciences Division
Montana State Dept. of Health and
Environmental Sciences
Cogswell Building
Helena 59601

Air:

Air Quality Bureau

Water:

Water Quality Bureau

Noise:

Occupational Health Bureau

Solid Wastes:

Solid Waste Section

Nebraska

Coordinating Agency:

Dept. of Environmental Control
Box 94653, State House Station
Lincoln 68509
(address central for all agencies)

Air:

Air Pollution Division

Water:

Head
Water Pollution Control Division

Chief
Agricultural Pollution

Nebraska (cont)

Solid Wastes:

Division of Solid Waste Pollution

Nevada

Coordinating Agency:

Bureau of Environmental Health
Dept. of Human Resources
Nye Building, 201 Fall St.
Carson City 89801
(address central for all agencies)

Air:

Air Quality Center

Water:

Public Health Engineer

Solid Wastes:

Public Health Engineer

New Hampshire

Air:

New Hampshire Air Pollution Control Agency
Laboratory Bldg.
Hazen Drive
Concord 03301

Water:

Water Supply & Pollution Control Commission
P.O. Box 95
Concord 03301

Solid Wastes:

Division of Food and Chemistry
Laboratory Bldg.
Hazen Drive
Concord 03301

Coastal Resources:

Division of Resources and Environmental Development
State House Annex
Concord 03301

New Jersey

Coordinating Agency:

Dept. of Environmental Protection
P.O. Box 1390
Trenton 08625
(address central for all agencies)

Air:

Bureau of Air Pollution Control
Division of Environmental Quality

Water:

Water Pollution Control

Noise:

Office of Noise Control

Solid Wastes:

Bureau of Solid Waste Management

Land Use Control:

Land Acquisition

New Mexico

Coordinating Agency:

Occupational Health & Radiation
PERA Bldg.
College and W. Manhattan
Sante Fe 87501

Air:

Air Quality Division

Water:

Water Quality Division

Solid Wastes and Land Use Control:

General Sanitation Division

New York

Coordinating Agency:

New York (cont)

Environmental Conservation
New York State Dept. of Environmental Conservation
50 Wolf Rd.
Albany 12201
(address central for all agencies)

Air:

Air Pollution Control Program

Water:

Enforcement Section
Division of Pure Waters

Noise:

Office of Noise Control

Solid Wastes:

Division of Solid Waste

Land Use Control:

Director of Planning

Coastal Resources:

Division of Marine & Coastal Resources

North Carolina

Coordinating Agency:

Office of Water & Air Resources
Dept. of Natural and Economic Resources
P.O. Box 27687
Raleigh 27611

Air:

Water and Air Quality Control

Water:

Asst. Director
Administration and Enforcement
Water Resources Development

North Dakota

Coordinating Agency:

North Dakota (cont)

North Dakota State Dept. of Health
State Capitol
Bismarck 58501
(address is central for all agencies)

Air:

Division of Engineering

Water:

Water Supply and Pollution Control

Noise:

State Health Dept.
Environmental Engineering Division

Solid Wastes:

Water Supply and Pollution Control

Ohio

Coordinating Agency:

Ohio Environmental Protection Agency
P.O. Box 1049
Columbus 43216

Oklahoma

Coordinating Agency:

Environmental Health Services
Oklahoma State Dept. of Health
N.E. 10th and Stonewall
Oklahoma City 73105
(address is central for all agencies)

Air:

Air Pollution Control Division

Water:

Water Quality Division

Noise:

Occupation and Radiological Health Division

Oklahoma (cont)

Solid Wastes:

Sanitation Division

Oregon

Coordinating Agnecy:

Dept. of Environmental Quality
1234 S.W. Morrison
Portland 97205
(address is central for all agencies)

Air:

Air Quality Controls Division

Water:

Water Quality Control Division

Noise:

Under above

Solid Wastes:

Solid Wastes Management Division

Pennsylvania

Coordinating Agency:

Bureau of Air Quality & Noise Control
P.O. Box 2063
Harrisburg 17120
(address is central for all agencies)

Air:

Above

Water:

Bureau of Water Quality Management

Solid Wastes:

Division of Solid Waste

Pennsylvania (cont)

Land Use Control:

Mines and Land Protection

Rhode Island

Air:

Rhode Island Division of Air Pollution Control
Room 204, Health Bldg.
Davis Street
Providence 20908
(address central except as otherwise noted)

Water:

Division of Water Supply and Pollution Control
Room 209

Noise:

Division of Occupational Health
Room 206

Solid Wastes:

Solid Waste Management
Room 204

South Carolina

Coordinating Agency:

South Carolina Dept. of Health and Environmental Control
J. Marion Sims Bldg.
Columbia 29201

South Dakota

Coordinating Agency:

Dept. of Environmental Protection
Room 415, State Office Building #2
Pierre 57501
(address central for all agencies)

Air:

Air Quality Program
Office of Air & Water Quality

South Dakota (cont)

Water:

Chief
Water Quality Program

Chief
Water Hygiene

Solid Wastes:

Office of Land Management and Solid Waste

Land Use Control:

Conservation Commission

Tennessee

Coordinating Agency:

Bureau of Environmental Health Services
349 Cordell Hull Bldg.
Nashville 37219
(address is central for all agencies unless otherwise noted)

Air:

Division of Air Pollution Control
Room C2-212

Water:

Water Quality Control
621 Cordell Hull Bldg.

Noise:

Division of Occupational and Radiological Health
Room 630

Solid Wastes:

Sanitation and Solid Waste Management
320 Capitol Hill Bldg.
Nashville 37219
Division of Sanitary Engineering
606 Cordell Hull Bldg.
Nashville 37219

Texas

Coordinating Agency:

Texas (cont)

Texas State Dept. of Health
Dept. of Waste Water Technology & Surveillance
1100 W. 49th Street
Austin 78756

Air:

Texas Air Control Board
8520 Shoal Creek Boulevard
Austin 78758

Water:

Executive Director
P.O. Box 13246, Capitol Station
Austin 78711

Noise:

Division of Occupational Health and Radiation Control
1100 W. 49th Street

Solid Wastes:

Division of Sanitary Engineering
1100 W. 49th Street
Austin 78756

Utah

Coordinating Agency:

Utah State Division of Health
44 Medical Dr.
Salt Lake City 84113
(address is central for all agencies)

Air:

Air Quality Section

Water:

Executive Secretary
Water Pollution Committee
Dept. of Social Services

Solid Wastes:

Bureau of Environmental Health

Vertmont

Coordinating Agency:

Environmental Engineering Division
Elm Street
Montpelier 05602

Water:

Agency of Environmental Conservation
Court Street
Montpelier 05602

Noise:

Industrial Hygiene Division
Barre 05641

Solid Wastes:

Elm Street
Montpelier 05602

Land Use Control:

Land Use Administrator
Agency for Environmental Conservation
Court Street
Montpelier 05602

Virginia

Air:

State Air Pollution Control Board
Room 1106, Ninth Street Office Bldg.
Richmond 23230

Water:

State Water Control Board
Same as above

Washington

Coordinating Agency:

Division of Standards and Criteria
Dept. of Ecology
Olympia 98504

West Virginia

Air:

West Virginia Air Pollution Control Commission
1558 Washington Street E.
Charleston 25311

Water:

Division of Water Resources
1201 Greenbrier Street
Charleston 25311

Solid Wastes:

Solid Waste Program, Dept. of Health
1800 Washington Street E.
Room 554
Charleston 25305

Wisconsin

Coordinating Agency:

Division of Environmental Protection
4610 University Ave.
Madison 53705

Air and Noise:

Air pollution Control Section

Water:

Director
Bureau of Water Supply and Pollution Control

Director
Bureau of Standards and Surveys

Solid Wastes:

Solid Waste Disposal Section

Wyoming

Coordinating Agency:

Dept of Environmental Quality
State Office Bldg.
Cheyenne 82202

Air:

Air Quality Division

Wyoming (cont)

Water:

Water Quality Division

Land Use:

Land Quality Division

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